NEW SERIES, NO. 130 (VOL. XVII) JUNE, 1920

QUARTERLY PUBLICATION OF THE

AMERICAN STATISTICAL ASSOCIATION

Price $1.00 1920 $3.00 Per Annum

Published quarterly by the American Statistical Association
RUMFORD PRESS BUILDING, CONCORD, N. H.
Editorial Office, New York City
Entered at the post-office, Concord, N. H., as second-class mail matter

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COST OF PRODUCTION STATISTICS*

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THE ECONOMIC VS. THE ACCOUNTING CONCEPT OF COST

I. THE IMPORTANCE OF COST OF PRODUCTION STATISTICS

The importance of cost of production statistics is suggested by a mere reference to their use in connection with (1) price control, (2) taxation, (3) wage problems, (4) comparative efficiency studies, and (5) improvement of competitive conditions.

Cost of production statistics would make for *efficiency in production.* They would increase the possibility of comparative-efficiency studies, which would make the struggle for survival among different methods more intelligent. They would throw light on the vitally important question of relative efficiency of large and small scale business units. And in this connection, I would invite attention to the Federal Trade Commission's report on the cost of producing copper, in which (on page 18) it is made clear that the cost per pound varies almost inversely with the output.

I would especially call attention to the fact that cost of production statistics, if reasonably comprehensive, would be a step in the direction of encouraging *reasonable competition.* We hear much talk of reasonable restraint of trade; on the other hand, we know that there is cut-throat competition. This competition arises frequently from a lack of knowledge of cost. The collection of cost of production statistics would be invaluable as an education to the business men of the country. I think it may safely be said that if each and every producer knew his own true cost, competition would be revolutionized. Indeed, on the assumption which I have just made, it might safely be hoped that economic theory would go far toward fitting actual indus-

* Read before the eighty-first annual meeting of the American Statistical Association.

trial facts, for ignorance has always stood in the way of the possibility of applying the economic theory.

In addition to these more practical advantages, there is every reason to believe that economic and statistical theory would be greatly enriched and to some extent corrected by the collection of cost statistics. Such work as has been done thus far certainly whets the scientific appetite. I refer to the recently published cost studies of the Federal Trade Commission (coal, copper, etc.) and the report of the Tariff Commission on costs in the sugar industry. Such studies may enable us to answer conclusively such questions as: What scale of operations is most economical? Is large-scale operation ever profitable in agriculture? What proportion of total cost consists of "labor"? Is there any profit at the margin? The importance of presenting series of cost figures and of throwing light on dispersion, will be apparent.

Proceeding largely on the basis of my recollection of the data I observed when connected with the Federal Trade Commission, I will venture to say that in the case of such industries as copper, lumber, coal, sugar, and cement, the following points will be found to be true:

(1) Commonly, the costs of different plants vary widely, a range of as much as 100 per cent being frequent.

(2) If curves be plotted representing a series of company or plant costs, they will be found to have a rather uniform and regular, though somewhat asymmetrical shape, owing to the fact that a majority of the plants are grouped not far from the average cost, with relatively small groups of high-cost and low-cost companies at the extremes.

(3) Somewhat over half the output in any industry (of the class indicated), however, will come from companies whose costs are less than the average; but this does not mean that the larger plants or companies will have the lowest costs. Put in another way, the weighted average cost will be somewhat less than the simple average of company or plant costs, though not necessarily much less. It will also be lower than the median cost, but will sometimes be greater than the modal cost.

(4) The modal cost may be greater or less than the median cost in the series, depending to a considerable extent upon whether the number of relatively high-cost units (companies or plants) is great enough to pull up the median. (Monopolistic control, enabling inefficient producers to survive, is often indicated by a modal cost which is much lower than the median. It is interesting to note that this situation is indicated to exist in some of the industries investigated by the Federal Trade Commission, these often being pathological cases!)

(5) Ordinarily a considerable percentage of the output will be found to come from plants or companies whose total costs are higher than the

price of the product sold, perhaps between 10 per cent and 20 per cent of the total output coming from such extra-marginal concerns.

(6) There will generally be a sharp break upwards in the cost curve at this point, which will often correspond to the marginal point.

(7) A little lower on the cost curve, there will generally be a more gradual rise, commencing at a cost which will cover from 70 to 75 per cent of the total output. This point will often correspond to the modal cost.

The foregoing generalizations are illustrated by the following cost statistics taken from reports of the Federal Trade Commission:

NEWS PRINT PAPER COSTS, 1915

Cost Groups	No. of Mills	Produced (Tons)	Per Cent of Total	Avg. Cost per Ton
Less than $27	3	195,830	19.1	$26.64
$27 and less than $30	2	138,934	13.5	28.51
$30 and less than $33	8	260,505	25.4	31.64
$33 and less than $36	11	276,672	27.0	34.75
$36 and less than $40	8	120,199	11.7	37.74
$40 and over	3	33,321	3.3	43.67
Total	35	1,025,461	100.0	$32.21

Average cost	$32.21 = 60% of output
Median	34.58 = 85% " "
Mode (est.)	35.17 = 85% " "

Range of costs: $25.77 to $44.41 per ton.
Average price = $38.45*

* Average net realization

COPPER COSTS, 1918

Cost Groups	No. of Companies	Production 1918	Per Cent of Total	Accumulated Per Cent
Cost less than 12 cents	2	122,245,051	5.41	5.41
Cost between 12 and 13 cents	4	208,571,191	9.24	14.65
Cost between 13 and 14 cents	4	314,553,177	13.93	28.58
Cost between 14 and 15 cents	4	359,617,743	15.92	44.50
Cost between 15 and 16 cents	2	98,307,293	4.35	48.85
Cost between 16 and 17 cents	8	460,528,645	20.39	69.24
Cost between 17 and 18 cents	9	255,399,696	11.32	80.56
Cost between 18 and 19 cents	3	72,373,388	3.20	83.76
Cost between 19 and 20 cents	5	28,491,436	1.26	85.06
Cost between 20 and 21 cents	5	36,871,193	1.63	86.65
Cost between 21 and 22 cents	9	135,538,602	6.00	92.65
Cost between 22 and 23 cents	3	60,861,465	2.70	95.34
Cost between 23 and 24 cents	5	44,919,772	1.99	97.32
Cost between 24 and 25 cents	1	6,230,604	.28	97.66
Cost between 25 and 26 cents	3	7,605,224	.34	97.90
Cost over 26 cents	18	46,119,555	2.04	100.05
Total all companies	85	2,258,234,125	100.00	....

Average cost	16.17 cents = 69% of output
Median (est.)	20 cents = 85% " "
Mode (est.)	17+ cents = 80% " "

Range of costs = about 10 cents to over 30 cents per pound.
Average price = 24.7 cents per pound.*

* Price fixed by the War Industries Board.

It will be observed that over 60 per cent of the output comes from companies or mills producing at costs under the weighted average, and that about 80 per cent of the output is covered by the modal cost. In comparing costs and prices, allowance for interest on investment may be made by remembering that the average investment per pound of copper was $0.30, so that 1.5 cents would yield 5 per cent. Also, that paper mills realized an average gross profit of $5.60 per ton from average net sales of $38.45,* which yielded about 6 per cent on the average investment; *i. e.*, $5 per ton would about yield 5 per cent on investment. At this rate, 16 out of 35 mills failed to make more than bare interest on investment, and 5 showed a positive loss.

II. THE NATURE OF COST, AND THE ESSENTIALS OF A STATISTICAL CONCEPT OF COST

There are almost as many ways of defining cost as there are different interests actuating men or groups of men in production. The greatest line of cleavage in defining costs, however, is that which lies between society and the individual.

Put in the most general terms, from the social point of view, cost is the measure of the obstacles to that human activity which is directed toward the gratification of human desires. It is thus a factor in determining motives and in directing activity in production, and it owes its significance in the last analysis to its power to motivate the producer. This definition of cost can be generalized, since it does not lead to duplications or to the inclusion of elements of surplus. It is not dependant upon price, but can be used in the analysis of price determination. It is in line with the conception of costs as composed of the pains and sacrifices of those engaged in production. But note that it is broader than "pain cost" in that it would include the exhaustion of natural resources. Robinson Crusoe on the desert island had to husband his scanty supply of powder; and with a nation, or a society, the facts that there is a limited supply of some raw material that is necessary to the life of that nation or society, and that this resource is being exhausted by production, become very significant: this condition acts as a sort of obstacle to the gratification of desires. In fact, the scope of cost becomes broadened as men's appreciation of the future becomes keener, as is illustrated by the fact that the conservation movement of today has become associated with a growing emphasis of "depletion" as an element in cost.

Individual costs differ from social costs. The end of mere individual human activity is largely, though not necessarily entirely, selfish,

* The price of paper was low and rose rapidly from 1915 to 1916.

since it is generally concerned with the welfare of the individual and his immediate family circle or business unit. The obstacles to his activity are largely obstacles to his money-making, and his costs are generally counted as money costs. Again, from the mere individual point of view, the choice between two gains, one of which must be foregone, may seem to be an immediately motivating factor; and this has been called "opportunity cost." Also, because the individual necessarily takes a short-time point of view, it follows that he has but a very remote appreciation of the cost aspect of the exhaustion of natural resources.

Costs considered from social and individual points of view may bring the same result, if the individual actions do not clash with social welfare. An obvious case occurs in the use of labor-saving devices. A cement company may desire to install boilers and flues for the purpose of saving waste heat and recovering potash, which will both reduce the owner's money-cost, and benefit the public.

But costs from the two points of view may also conflict. Social ends, as compared with individual ends, are broader in space and more distant in time. Also, the ultimate obstacles to human activity from the social point of view do not lie in things which prevent mere money-making, but in things which limit the net increase of articles of consumption. We need continually to heed the old reminder that money-making is not necessarily production. From the social point of view, the fact that limited supplies of coal, oil, or copper are being exhausted makes it essential that each ton, barrel, or pound be counted as cost; but to the individual mine-owner, it may seem quite unnecessary to "figure depletion." Or, the individual may seek to capitalize "opportunity" by charging some raw material which he owns into his "cost of production" at the market value, instead of at its actual cost. He may deceive the public and even himself as to his true net earnings, and thus prevent the full exploitation of that material which would be in the public interest. Such individualistic manipulations make costs either too little or too big from the social point of view, tending either to retarded production or to wasteful over-production. Moreover, such procedure defeats the very purpose of statistics, for the particular "opportunity," or appraised market-value, "costs," being hypothetical and estimated, cannot be counted as actual things, and if taken as estimates, are bound to result in hopeless duplication or in the inclusion of elements of surplus. They cannot be generalized.

In my judgment, an important problem in connection with cost of production statistics is so to define costs that statistics of cost will bring us correct results from a true social point of view. The true

point of view must be one that, while recognizing the existence of individual interest, will seek to harmonize individual or class interests; one which, in other words, will combine the two points of view—one which can be generalized.

Another distinction which has to be drawn is that between *economic costs and accounting costs.*

The accountant, in his work, necessarily takes a rather individualistic point of view, for he is employed to "get results" for an individual business.

He is concerned with money costs. Costs, from the accountant's point of view, represent actual money paid out. They concern the administration of the operations of the business unit, and consist of payments made for the labor which may be hired, for material which must be purchased, and for such general expenditures as are incurred, including depreciation. When the business is forced to borrow money to meet some current obligation, or when it is forced to rent a piece of land or a building, the interest paid on the money borrowed, and the rent actually paid, are items of out-go which cannot be funded or capitalized, but must be met if the business is to continue. Such payments are therefore costs. It follows that accounting costs are tangible and of record. They can be counted. They do not, however, reveal true total payments for the several economic factors. The "labor" item as generally found on the books is merely the "pay-roll" and does not include either the administrative or managerial labor, or the "labor" tied up in purchased raw materials in non-integrated concerns, and in "materials and supplies" in all concerns. Moreover, the interest and rent items can truly include only the amounts paid out, which do not correspond to the economist's "shares"; and in accounts there is confusion between land and buildings, as is general in the business world.

The accountant deals with the relations between a particular owner and his particular business, accounts being designed for the purpose of exhibiting exactly this relation. It follows, therefore, that the accountant regards rent on the particular property owned, and interest on the particular investment as income, for they come in to the owner (his employer) from his property or business. He cannot consider all capital goods, nor account for the total interest share.

In fact, rent on property owned, interest on the investment, and profits, are inseparable in accounting. They cannot be regarded as out-go, and so are not costs to the accountant. There is always a financial purpose of enabling the owner to deduct from his particular income the necessary out-of-pocket payments, in order that he may as-

certain what is his true net income. It is only when such income is ascertained that interest on investment and profits can be known.

Obviously, the sum of particular accounting costs does not correspond to the sum of economic costs. With books kept as at present, we cannot get even the true total labor expense for any given product, especially in case the production is non-integrated. Moreover, salaries are often either nominal, or represent a distribution of profit; and materials, raw and other, are charged at fluctuating market values. Interest does not represent the cost of the capitalist, but merely a contractual payment on sums borrowed; and estimated interest on investment is hopelessly mixed with profits, rent, and hypothesis.

It is to be noted that from the accountant's point of view, costs concern payments made by the *producer*, and not payments made by the *consumer*. It follows that from the accountant's point of view, cost cannot normally equal price, but will be somewhat less.

The economist's costs are somewhat different from accounting costs. He has to consider from the point of view of society the problem of the total supply of capital goods, and the direction of their use. His interest in any particular investment and the return thereon, is incidental. He is therefore concerned with interest as representing a social cost. Economic theory can and does separate rent, interest, and profits; for it is not concerned with the profit and loss sheet of a given business or of any particular property. To the economist as a student of normal competitive conditions, cost is not what the owner or operator pays out, but is the equivalent of what the consumer pays, and he considers it both from the point of view of the consumer and from the point of view of its effect upon production. Therefore, his cost must equal the price. Price, he regards as an expression of the forces tending to equilibrate demand and supply.

It should be observed that there is a small minority among both accountants and economists who are seeking to combine the two points of view and make accounting and economic costs identical. Among economists this minority consists of those who would recognize the so-called "opportunity cost" as a price-determining cost. A few accountants would treat interest on investment as operating cost. Although they have very diverse motives and interests, both of these groups assume an extremely individualistic point of view, and proceed upon the assumption that price determines cost. With both, the costs are not actual, but hypothetical. Both would disregard the interests of society in seeking to equalize the inefficient or the parasitical with the efficient and the socially productive.

In the reference already made to accounting costs, the distinction

between the owner and the operator has been pointed out, and this distinction is essential if the various conditions which arise in dealing with accounting costs are to be understood. The owner stands for capital; the operator for enterprise, which is generally identified with the manager. Accordingly, the accounts which will satisfy the mere owner's interest are not at all those which would satisfy the operator. Owner accounts concern the relation between the owner and his property, and consist primarily of a balance sheet and an income account or profit and loss statement. Operator accounts show the relation between the operator or manager and the operation which he directs, and consist primarily of "cost sheets," which have their relation to the owner accounts in that they must be carried into the profit and loss statement, which in turn serves to connect the income account with the balance sheet. The owner's accounts center in profits, including interest on investment; the operator's accounts center in out-go costs, including wages, materials, and general expenses.

Closely parallel to the foregoing distinction is the distinction between "cost of sales" and "cost of production." By "cost of sales" is here meant cost in the sense of all deductions made from operating income, and such costs are reducible to a unit basis by using the quantity sold as a divisor. In getting the cost of sales, therefore, we have to consider the change in total value of inventories. To the operating man, the fact that the value of inventories decreases during a given period of time makes no difference, but to the owner, it may be of vital importance. In order to ascertain the profit or loss for the business, it is necessary that a net decrease in the total value of inventories be added to cost, and it is only thus that cost can, as the phrase runs, "tie into" the profit and loss account, and thus into the balance sheet. The quantity sold must be used as the divisor, for the owner is concerned, after all, not with what is produced, but with what is marketed; not directly with cost, but with total net income.

It should be noted, too, that the cost of sales is but a hypothetical cost, including as it does an estimated value of inventories, which being stock on hand has not been sold, and might, if actually put upon the market, bring a different price from that at which it is carried on the books.

Production cost, or output cost, as it might be called to distinguish it from cost of sales, does not consider inventories, but represents what it actually would cost at the present time to replace the stocks of product on hand. The divisor used is the quantity actually produced during the period of time under consideration, and the dividend is the sum of the operating expenses actually paid out or chargeable to the operation

involved in the production of the quantity used as a divisor. It is production or output cost, as distinguished from cost of sales, with which the nation or society is interested, and which should be used for the purpose of regulating prices.

Another phase of the distinction between owner costs and operator costs is suggested by the terms "conversion" and "capital replacement." The owner is interested in capital replacement, but this is not true of the operator, as such. In accounting, conversion, or manufacturing cost, is the operating expense strictly construed, and consists of payments made by the operator for labor, materials, etc. It may include interest actually paid on money borrowed to meet current expense, but not interest on investment. Such conversion cost will include maintenance and repairs which are required to keep the plant and equipment going, but not depreciation which is over and above maintenance and repairs, and occurs in spite of them. Capital-replacement cost, on the other hand, concerns the charges necessarily made to return to the owner his property when it is worn out or exhausted, and may be divided into three heads, depreciation, extinguishment, depletion. The last two are less understood, and a word may be added concerning them. If a lumber mill buys timber land sufficient to enable it to operate for ten years, it constructs a railway for logging supplies, and a saw-mill, installing all equipment connected with these operations. It may build a town, and establish a commissary. The life of these items may be considerably longer than ten years. It therefore becomes proper and necessary for the lumber man to write off the cost of his plant over a period of ten years, and this is what is meant by extinguishment charges. Depletion is similar, but concerns the exhaustion of the raw material itself.

It will be observed that "capital replacement costs" do not exactly coincide with "owner costs" (as distinguished from operating costs), since they include wear and tear, which is an operating item. Also, although they bear some relation to cost of sales, in regarding inventories as an item of capital, the two costs are otherwise quite different.

With the foregoing distinctions in mind, we may say that in laying a basis for cost of production statistics:

1. We must proceed from a social point of view, which will consider as costs things which will actually motivate individuals, but which exclude factors that cannot be generalized, either because they tend to destroy society by motivating anti-social activities of individuals, or because they involve duplication (or negation).

2. We must secure data from accounts and accounting costs, but we must use them to portray economic facts. Ultimate economic costs

cannot be counted; we probably can never hope for very close statistical measurement of sacrifices, pains, or exhaustion of natural resources. Accounting costs are the only actual data available. (The so-called "entrepreneur costs," if they mean anything different from accounting costs, are unreal or even socially vicious, to say nothing of the duplications or negations that would result from an attempt to enumerate and total them.)

3. There are important limitations on accounting data which must be removed if true statistical results are to be gained. (a) Accounts cannot show us the total labor cost, to say nothing of interest, uninsurable hazards, and rent. (b) Accounts require much analysis to eliminate false items and duplication. (We cannot assume that errors will offset each other.) (c) Accounts probably will never show us the true total cost of any good, as they include a considerable element of goods and services taken in at market values. This may be especially difficult to deal with when a good is procured by a series of non-integrated concerns.

4. We will be interested primarily in cost of production, not of sales, as it is this which determines public policy and private activity in the long run.

5. We should include items from both owner and operator costs, taking in both conversion and capital-replacement charges. In this connection it is essential to secure accurate data on cost of investment.

The problem all the way through is to prevent the taking of interest and profits on any *particular* investment for granted, or in other words, to prevent giving out statistics which will tend to establish a guarantee of rates on any particular investment. Also, conversely, a second problem is to establish conditions based on statistical information which will help wise and honest investments to make a fair rate of return.

Concretely stated, the foregoing distinctions may be applied, and an approximation to the solution of the foregoing problems be reached, by making our costs include certain items which are sometimes not included, and excluding certain items which are often included. Some of the more important, according to my experience, are as follows:

Items to be included in cost:

(1) Depreciation
(2) Extinguishment
(3) Depletion
(4) Wages of managers and executives
(5) Losses due to shrinkage, spoilage, etc.

Items to be excluded from cost:

(1) Charges against income (excess profit taxes, interest on investment, etc.)

(2) Contingency reserves and uninsurable hazards
(3) Distribution of profits (excessive salaries)
(4) Inter-company profits and inter-departmental profits
(5) Capital charges
(6) Costs not properly connected with the given operation or time, ("outside operations," undue proportion of long-time charges)

Items required in addition to cost:

(1) Investment (actual expense and depreciation charged off in the past)
  (a) Reserves of raw materials (ore, oil, stumpage, etc.)
  (b) Land (factory and office sites)
  (c) Plant and equipment (buildings, machinery, etc.)
(2) Property used in addition (leased, etc.)
  (a), (b), (c), as above.

If we continue to use accounting costs, we should do so with a more intelligent appreciation of their limitations. In any case, we can forswear that hybrid monster which the economist calls "opportunity cost," and the accountant calls "interest on investment."

III. SOME PRACTICAL QUESTIONS CONNECTED WITH THE COLLECTION, COMPILATION, AND PRESENTATION OF COST OF PRODUCTION STATISTICS

How should cost-of-production statistics be collected? It would involve a very careful preliminary study of representative companies in each industry selected. As a result, a schedule, or schedules, would be prepared, and would be the basis for collecting the bulk of the data required. There would have to be a check with the books of representative companies, which makes it important that the body collecting the figures should have power by law to go to the books and records. I may say that my experience convinces me that even the best of cost schedules cannot be entirely satisfactory, and that questions are bound to arise which must be answered by correspondence, and in many cases, by scrutiny of the accounts. In this connection, it will be important at times to check the cost figures into the profit and loss account; and the schedule, to be satisfactory, must certainly call for a statement of the actual investment and depreciation, and such controlling figures as the quantity produced, quantity sold, the total expense, the addition to surplus, and the distribution of profit.

The scope of cost of production statistics would be an important matter to decide. The industries to be covered would be decided on the basis of their importance and the known difficulties of getting satisfactory results from them. It would be expedient to consider the advisability of going on with the work already done by the Federal Trade Commission and other bodies, covering such industries as coal, steel,

oil, lumber, sugar, and copper. In not a few cases it will be found necessary to await accounting progress. In more than one industry of considerable magnitude, it will today be found virtually impossible to secure accurate cost data.

The areas, and the numbers of companies to be covered, may be various, and it will be found impossible to cover 100 per cent of the production in most if not all cases. The smallest companies, especially if it is assumed that these are the least efficient, may be omitted. The remaining companies may be grouped and graded, and a simpler schedule used for the smaller companies, with a more detailed one for the larger, for the latter generally have better accounts.

The frequency of reports is a matter of great importance, as the value of these figures, from a practical point of view, varies almost inversely with the time which elapses between the period covered and their presentation. On the other hand, the difficulty of securing current costs is enormous, for it may also be said that the correctness of cost figures varies almost inversely with the shortness of the period covered. Monthly or quarterly costs are bound to be rather unsatisfactory, inasmuch as certain items of expense have to be estimated and prorated. In some industries, like the production of rosin and turpentine, for example, where there is a seasonal cycle of production, it is doubtful if satisfactory figures can be secured for any period less than a year.

Perhaps the most interesting practical question is the consideration of the details with which the investigation would be concerned. In the first place, I will say that the costs should be analyzed into three great divisions, labor, materials, and expense. This is the most feasible distinction of public value that the accounts in general permit. Moreover, it has a practical advantage in the fact that most of the errors in cost statistics come in the item of "expense," and this segregation therefore would facilitate checking.

One great problem lies in the distinction between what we may call departmental costs and economic costs. Each department of a business, taking the material through various stages to the shipping stage, involves labor, materials and supplies, etc., and with the present accounting development, it probably would be impracticable to get these departmental costs satisfactorily. To give but one concrete reason, the item of "maintenance and repairs" is not available by departments in many industries. While costs by departments are extremely valuable to the manufacturer, it must be remembered that the total of departmental costs per unit will not check with the total cost of business, on account of the different quantities of material which pass through the different departments in any given period.

Two other suggestions: first, in handling joint costs, it would probably be wise at the outset to do no more than to attempt to get the average cost per unit of all the joint products combined, though it would be highly important to get the quantity and selling price for each product. Second, I would stress the importance of securing exact information as to the quantities produced, sold, and in inventory,—which, by the way, is a limiting factor, inasmuch as such figures are often much more difficult to secure than one would suppose.

In conclusion, I would point out that the amount of checking required is related to the degree of competition in the industry. It will be remembered that "costs" can be manufactured like any other product, and however optimistic we may be, we would be foolish to shut our eyes to the established fact that manipulation in costs is not only known to exist, but is known to exist frequently. Now, where we have monopoly, it is necessary to have compulsory access to books and returns must be carefully checked. Where we have limited competition a thorough check is necessary. Where, however, we have free competition—as is sometimes the case—we may accept the costs as reported by the company, with a great deal more assurance. However, considerable checking would be required, even here, as in matters of taxation, wage adjustments, etc., common motives would color men's treatment of cost, no matter how much competition there might be.

SUGGESTIONS AS TO THE LAWS OF CAPITAL RETURN UNDER CONDITIONS OF FREE COMPETITION*

By M. C. Rorty

In connection with the special interest that attaches, at the present time, to studies of costs of production and distribution, it is possible to suggest a complementary line of approach through the study of the actual rates of return on capital (including borrowed money) invested in productive and distributive enterprises. There is reason to believe that, in respect to such enterprises, operating under conditions of free competition, there are rather definite laws which govern the normal, or long period, distribution of the establishments and the invested capital by rates of capital return. The laws governing this distribution may be stated, tentatively, as follows:

1. Rates of capital return under conditions of free competition are determined not by the kind of production or distribution, but by certain constants, such as the ratio of invested capital to gross sales or output, the ratio of gross sales or output to the value added by manufacture or distribution, the relation of the business or industrial activity to the normal business cycle, *i. e.*, whether this activity fluctuates more widely or less widely than general business activity, etc.

2. In each particular line of production or distribution, prices are determined by the costs of operation of a group of establishments which earn, in the long run, only the rate of capital return reasonably necessary to maintain them.

3. In relation to this price-determining group of establishments, the entire investment in the industry, or distributive process, is arranged by rates of capital return in the form of a heavily skewed frequency curve, there being few establishments earning appreciably less than those of the price-determining group, but a very considerable number earning higher rates of return.

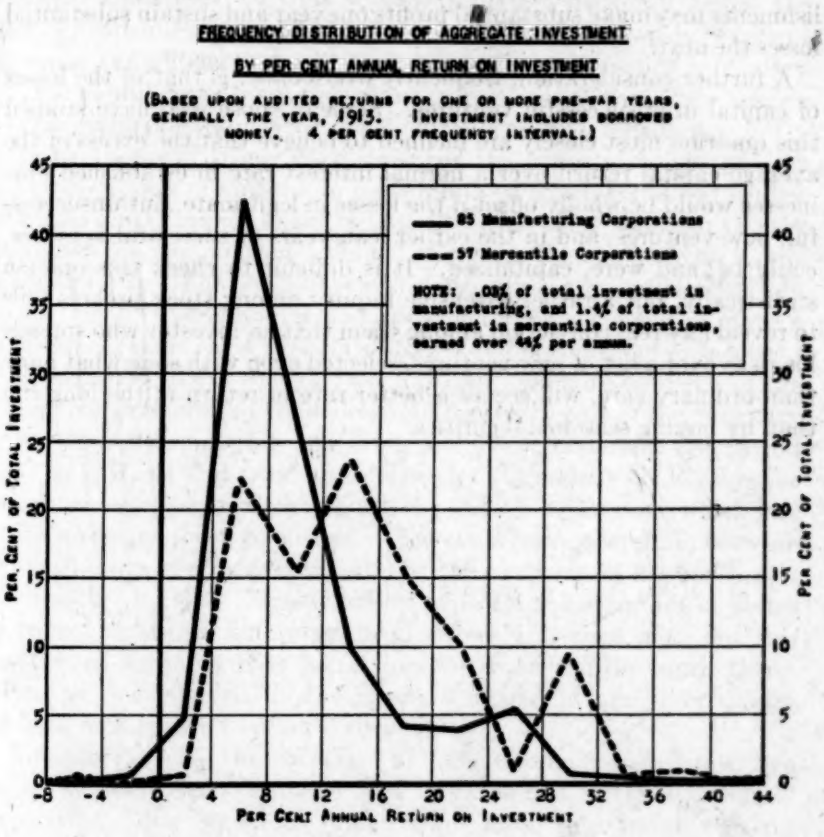
4. In industries or distributive processes where the rate of capital turn-over is high, where the ratio of value added by manufacture or distribution to the total value of output or sales is low, or where business activity fluctuates more widely than general business activity, the spread of the frequency curve is relatively great and the ratio of the average rate of capital return to the rate of capital return in the price-determining group is high.

The preceding suggestions as to the laws which govern capital re-

*Read before the eighty-first annual meeting of the American Statistical Association.

turn, and therefore prices, under conditions of free competition, cannot be looked upon as anything more than an indication of promising lines of investigation for the future. They have, however, been tested in a very limited way, through an analysis of the basic data used by Mr. J. E. Sterrett in the preparation of his article in "The American Economic Review" for March, 1916, from which data it has been possible to eliminate all figures for establishments not definitely known to be subject to active competition.

The accompanying curves indicate the results of this analysis and, so far as they go, bear out the assumptions previously made. The

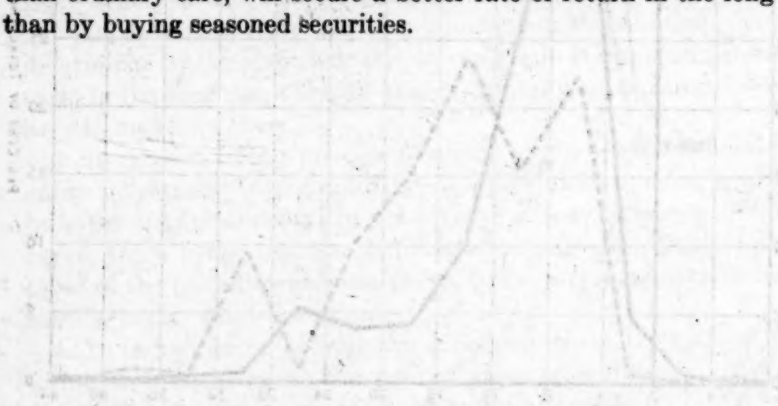


difference in the spread of the curves for manufacturing and mercantile establishments is particularly noticeable. It is hardly to be accounted for by accidental variations due to the small number of establishments considered, and may be assumed to be due mainly to the fact that the capital turn-over in manufacturing ordinarily does not exceed 200

per cent per annum, whereas this turn-over probably averages from 300 per cent to 400 per cent per annum in most mercantile businesses.

In connection with statistical studies of the kind under discussion, it is hardly necessary to indicate possible applications to questions of profit sharing, wage and price relations, excess profits taxes, and the basic distribution of national income. Regarding some of these questions, however, there is danger that entirely misleading conclusions may be arrived at, unless proper consideration is given to the fact that the general distribution of establishments by rates of capital return may remain relatively fixed, while at the same time individual establishments may make substantial profits one year and sustain substantial losses the next.

A further consideration, frequently overlooked, is that of the losses of capital in unsuccessful ventures. Some of those who have studied this question most closely are inclined to believe that the excess of the average capital return over a normal interest rate in established businesses would be wholly offset if the losses in legitimate, but unsuccessful, new ventures, and in the earlier lean years of successful ventures, could be, and were, capitalized. It is difficult to check this opinion statistically, but a rather extensive inquiry among stock brokers fails to reveal any real conviction among them that an investor who spreads his risks over a list of new ventures, selected even with somewhat more than ordinary care, will secure a better rate of return in the long run than by buying seasoned securities.



THE IMPROVEMENT OF CRIMINAL STATISTICS IN THE UNITED STATES*

By Louis N. Robinson, *Municipal Court of Philadelphia*

The beginnings of the Science of Criminal Statistics may be traced back to the year 1829. In that year, Guerry, whom Von Mayr regards as the founder of Moral Statistics,† published a small pamphlet on criminal statistics. On July 9, 1831, Quetelet delivered before the Royal Academy of Brussels his address, "Recherches sur le penchant au crime aux différens âges." With the further publication by Guerry in 1833 of his "Essai sur la statistique morale de la France," the science of criminal statistics may be said to have been fully launched.

In this country, New York state has the honor of being the first government unit of any size to collect data on which statistical studies of crimes and criminals might be based. In the same year that Guerry published his pamphlet on criminal statistics, that is, in 1829, it was made the duty of the clerks of courts of record to enter judgment of any conviction in their minutes and to send to the secretary of state a transcript of these entries ten days after the adjournment of such court.‡ Such material, it was thought, would furnish valuable evidence of the former convictions of old offenders. In the first report of the Secretary of State on this material, appearing in 1838 and covering the period 1830 to 1837, we find frequent references to Quetelet's book, *Physique sociale, un essai sur le développement des facultés de l'homme*, which had in the meantime been published. The connection, therefore, between the beginnings of criminal statistics on the continent of Europe and in this country is close. Massachusetts and Maine were the next states to collect statistical information on crimes and criminals, and this practice, of compiling data taken from the records of the courts themselves, or from material in the hands of district attorneys or similar officials, soon spread to other states.

Not content with the collection of judicial criminal statistics, two states, Massachusetts first and New York second, in 1834 and 1839 respectively, determined to obtain from those into whose custody prisoners were placed, *i. e.*, the keepers and the sheriffs, certain data somewhat analogous to that obtained from the courts and the court officials. In my book the *History and Organization of Criminal Statistics in the United States*, I have termed statistics of this kind "prison crimi-

* Read before the eighty-first annual meeting of the American Statistical Association.
† *Statistik und Gesellschaftslehre* (1895), vol. 1, p. 185.
‡ Robinson, Louis N., *Criminal Statistics in the United States*, p. 46.

nal statistics" in order to differentiate between the two sources of statistics of crime and criminals.

The establishment of state boards of charities and correction and of state boards of control has given a further impetus to the collection of both judicial and criminal statistics, and the recent movement to create state departments of public welfare may be expected to further the development of each form of criminal statistics.

Turning now to the efforts to obtain criminal statistics for the country as a whole, we find that it was not until the census of 1850, twenty-one years after New York had begun the task, that the Federal Government became sufficiently interested to collect information of this character, and even then it was done only in a meager and half-hearted way. In fact it was not until 1880, when Mr. Frederick H. Wines was placed in charge of the division of Social Statistics relating to pauperism and crime that a genuine attempt was made to give to the public a statistical picture of our criminal population. Again in 1890, Mr. Wines was placed in charge of this work, and the plan of 1880, with some slight modification, was carried out. Owing to the fact that the work of the decennial enumeration in 1900 was limited to the inquiries relating to population, mortality, agriculture, and manufactures, the collection of criminal statistics by the Bureau of the Census was not made again until 1904.

Although Mr. Wines had planned in 1880 to compile facts obtainable from court dockets, he seemed to have met with little success, and the effort was not repeated by the census officials until 1907. This attempt also proved a failure, and we must, therefore, confess to the world that as a nation we have not yet been able to do more than to collect what I have termed prison criminal statistics, and these only at long intervals.

In 1904, a change in the policy of collecting the prison criminal statistics was made. In 1880, and again in 1890, the statistics dealt with those in prisons on a certain day of the year, but in 1904 the emphasis was placed on those who had been committed during the year, a practice which was followed in the enumeration of 1910 and which all statisticians today will agree ought to have been inaugurated at the beginning.

In 1911, I stated that the criminal statistics which were put out by state governments were, almost without exception, poor, and I have seen little reason to change my opinion of their character since that time. The best criminal statistics we have are those published by the Federal Bureau of the Census, and these are far from satisfactory for two reasons: first, because they appear at such long intervals, and secondly, because they are based on data obtained from institutions

and not from records of the courts and are, therefore, very incomplete, since they do not include those whose punishment is other than commitment. For example, the total number of juvenile offenders committed to juvenile reformatories during the year 1910, is given in the *Report of the Bureau of the Census* as 14,197.* During the calendar year 1919, 1,242 juvenile offenders were placed on probation by the Municipal Court of Philadelphia alone, a little more than one-twelfth of the total number committed in the United States to juvenile institutions during the calendar year 1910, and more than any one of the forty-eight states, with the exception of New York, committed during that year.

From the summary which I have given of the history of criminal statistics in the United States, it is evident that the beginnings of criminal statistics in Europe antedated by only a few years the beginnings in this country. We cannot, therefore, attribute our poor showing to the newness of the venture. I am not concerned in this paper with an enumeration of our excuses, although it is true that an examination of a few of them will have to be made rather carefully in planning for the future.

Before taking up the problem of improving our criminal statistics, I feel that we should ask ourselves whether this effort is worth while. We know that all the principal European countries have for many years published excellent reports on criminal statistics and have seemed to feel that the work was well worth doing. I, for my part, feel that in the recent report of the Bureau of the Census we can find good reason for continuing the collection of these statistics, incomplete as they are, if we can do no better. I find, for example, that "Of the 493,934 prisoners and juvenile delinquents committed to penal or reformatory institutions in 1910, 278,914, or 56.5 per cent, were committed for non-payment of fine."† That fact alone is sufficient to justify the whole inquiry, since it throws into sharp relief what many of us have long contended, that the poor in this land do not get a square deal from the courts. Let me quote another statement from the same report: "Of the total number of commitments in the year 1910, 170,977, representing 34.6 per cent, or more than one-third, were for drunkenness; 91,928, representing 18.6 per cent, or almost one-fifth, were for disorderly conduct; and 50,302, or 10.2 per cent, were for vagrancy."‡ Together these three crimes account for 63.4 per cent of the total number committed. Even this partial picture, a 63.4 per cent picture, of our criminal class in so far as it is represented

* "Prisoners and Juvenile Delinquents, 1910," p. 158.
† "Prisoners and Juvenile Delinquents in the United States, 1910," *loc. cit.*, p. 41.
‡ *Ibid.*, p. 30.

by commitments is, in my opinion, a good and sufficient excuse for the time and money spent on getting together the facts. I fully recognize, too, the importance of the studies of individual delinquents made by Healy and others. Their usefulness cannot be exaggerated; but on the other hand they do not constitute a substitute for criminal statistics. Like the work of Le Play, these studies give us information that criminal statistics cannot offer; but it can also be said that criminal statistics afford us information equally valuable, which studies of individual delinquents cannot in the nature of things yield to us.

No student of criminal statistics will be content ultimately with anything less than the collection each year by the Bureau of the Census, of judicial criminal statistics, that is, of statistics made up of data obtained from court records for the country as a whole. I have already pointed out that the prison criminal statistics which the federal government now collects are very incomplete, and with the growth of probation and the development of yet other forms of treatment not of an institutional type these statistics must become still less reliable as a statement of our budget of crimes and criminals. Each one of the years of this new century has seen vast and far-reaching changes in our social system, and we should not have to wait for ten years to find out what these have meant in the way of increasing or decreasing crimes, or altering the composition of our criminal population. I shall look at the problem, therefore, with regard to the ways in which the federal government may secure better judicial criminal statistics.

Let us now return to the plan which the Bureau of the Census inaugurated in 1907. It was decided, I believe, at the outset to limit the scope of the work to certain states and counties. Special agents or clerks were sent into the territory selected and were instructed to copy on individual schedules from court records certain facts regarding each and every criminal handled by the courts during the calendar year 1906. I am sorry that I am unable to give the story of this attempt. It is well known, however, that it failed and that no report containing the facts thus collected ever appeared. Some weeks ago, I made a careful study of all court records, such as the special agents would have consulted in Philadelphia, and I was interested to learn that there is no record of any kind which would yield the social facts relating to the accused individual, questions 16 to 23 inclusive, which were called for on the individual schedule. Neither the transcript from the office of the magistrate, nor the bill of indictment; neither the judge's docket nor the minute book of the clerk, contained any information which would have aided the special agent to fill out his schedule. It would appear, therefore, that one reason for the failure

of this inquiry of 1907 was the absence of a large part of the data called for, and one deduction which can easily be made is that to have secured any success whatsoever, so far as Philadelphia statistics were concerned, the individual schedules should have been in the hands of the clerks of court, or some other official selected for the task, at the beginning of the year 1906. Possibly by paying a small sum for each case, they could have been induced to fill in the schedule as the business of the courts progressed.

I wish now to call attention to the records which are kept by some of our juvenile courts and by other courts of like procedure. Juvenile courts took over from private philanthropic agencies the idea of a face-sheet. There had grown up in private agencies the practice of placing on the first or face-sheet of each case record the relatively permanent facts concerning the case in question. Often attempts have been made to take off data from these face-sheets and to tabulate the facts for statistical purposes. Usually, the compilations have not been such as to merit much approval from statisticians, due perhaps to a lack of discrimination in the selection of facts found on the face-sheets, and to an absence of statistical training on the part of those who devised the face-sheets and also on the part of those who filled them out. An analysis of the average face-sheet reveals the fact that it contains information of three kinds: that necessary (a) for identification; (b) for handling or treating the case; and (c) that which may be considered as truly statistical in character. Failure to recognize these three purposes in a face-sheet has led first of all to an inaccurate formulation of the statistical questions, which should, of course, be made to harmonize both in form and in content with similar questions asked on the population schedule by the Bureau of the Census; secondly, it has led to the compiling of all the facts on the face-sheets, many of which have no scientific statistical value whatsoever. In the Municipal Court of Philadelphia we are now engaged in revising all our face-sheets. We are taking particular pains to have on the face-sheets the same questions which are found on the population schedule, and are printing instructions which will insure that the answers will be given in the same way. We intend to set up in our own court a system of record keeping which will yield all the information that is needed as a foundation for criminal statistics.

I maintain that before the records of our criminal courts are filed away in the burying ground of the Clerks of Quarter Sessions or similar officials, there should be something in the nature of a face-sheet attached either to the bill of indictment or to the record of the procedure before the court as a basis for criminal statistics. If this were done,

special agents could be sent around at regular intervals to copy the information. Otherwise, it can be obtained only by placing the schedules, as I have already suggested, in the hands of court clerks at the beginning of each year, or at the beginning of the year selected, and paying them for filling these out. The difficulty in this scheme is that if the clerk does not fill out the schedule when the accused is before him, he never will or can do it, since there is no record from which he can obtain this information afterwards. The Pennsylvania State Board of Public Charities makes no attempt to secure any social data from prothonotaries regarding the accused, from which I infer that court records throughout the state are similar to those which I found in Philadelphia.

Had time and leisure permitted, I should have liked to determine whether the records that are kept by the courts in other states are similar to those which I have observed in Philadelphia. My knowledge is too limited to enable me to suggest a complete plan for improving the criminal statistics of this country, and I must, therefore, content myself with making the following suggestions to the Bureau of the Census:

1. That the Bureau of the Census be requested to appoint either for full or part time a special agent whose duties shall be:

(a) To visit the various state boards or state officials charged with the collection of either prison or judicial statistics, and to ascertain the problems with which they are confronted in carrying on this work.

(b) To visit the offices of district attorneys, clerks of court, institutions, etc., and to examine their systems of record keeping with a view both to noting the facts therein contained and also to devising more adequate systems.

2. That the Bureau of the Census prepare a brief study of the jurisdiction of the courts in each state and keep the same up to date.

3. That on the basis of the report of the special agent and the study of the jurisdiction of the courts, a plan for the further improvement of criminal statistics be formulated, and the aid of such organizations as the American Institute of Criminal Law and Criminology and the Statistical Association be requested in putting the plan into effect.

No paper plan will succeed. Foundation work such as I have suggested will have to be undertaken. Surely, too, we have a right to look to the Bureau of the Census for the long persistent effort which will be needed to make criminal statistics a reality in the United States. Central guidance is also necessary, if there is not to develop such differences of practice by state boards and state officials as will render the task of whipping the statistics of the various states into a unified whole impossible. Many persons will say that the differences already

found in the states regarding penalties and definitions of crimes make the task unthinkable; but these differences have not prevented the collection of fairly good prison criminal statistics and they should not prove to be insurmountable obstacles in the collection of judicial criminal statistics.

Finally, let me say a word to statisticians. Most scientists are Prussians at heart, having as their goal a system of government wherein they will be fixed as bright and immovable stars. In a democracy, however, scientists must fight for their position and for their opinions as vigorously as the veriest ward politicians, and the sooner they realize this, the sooner will science exercise some influence in our government.

THE CONCEPTION OF STATISTICS AS A TECHNIQUE*

By John Cummings, *Federal Board for Vocational Education*

It seems significant that with few exceptions, those economists who were summoned to Washington during the war period to give counsel and aid in mobilizing our resources for war purposes, worked in the government offices not as economists but as statisticians, and that the services which they organized were officially designated statistical.

Under pressure of the war emergency each newly established war board or council or commission, which engaged actively in mobilization work, proceeded to build up more or less independently of existing services, and at the outset more or less independently of one another, a statistical service of its own. Schedules fluttered out from these offices, and descended in smothering snow-like masses over the whole community, one heavy fall being piled upon another, each federal office functioning as a statistical storm center. In a comparatively short period one office alone sent out over 400 different schedules.

Theories regarding economic conditions and phenomena were for the time being at a discount, and overnight the demand for data became overwhelming. In response to this demand schedule inquiries were instituted regarding stocks of materials, stores of commodities, equipment for war work, number of laborers of different skills, industrial consumption of specific materials, housing conditions, and in general regarding our available material resources.

Government offices, it may be noted, were at the outbreak of the war filled with statistical clerks, statistical technicians, machine operators, expert card punchers, sorters, and counters; and while these technicians with all their paraphernalia were obviously not as a class competent to undertake the statistical enterprises involved in mobilization for war, it is nevertheless probably true that the capacity of the permanent statistical service of the government to undertake the work which had to be done was somewhat underestimated. Some lost motion, confusion, and duplication, some experimenting by those unfamiliar with official statistical practice, and it must be added unfamiliar with available official statistics, might perhaps have been avoided, if the government had proceeded more generally to develop its statistical service from within. Experienced statisticians were, of course, not available either in the government service or in any other service in sufficient numbers to undertake and carry on effectively all

* Read before the eighty-first annual meeting of the American Statistical Association.

of the emergency statistical work which had to be done under pressure, but the policy of expanding existing services might nevertheless, it would seem, have been advantageously adopted more generally than it was, in preference to the policy of building up independent, uncoördinated, temporary services.

One unfortunate consequence of the policy adopted has been the sudden collapse of important statistical enterprises initiated during the war, some of which at least might well have been continued during the reconstruction period, if not permanently. On the whole, the process of statistical demobilization is proving to be nearly as disrupting as was the process of mobilization, and it is being found difficult now to provide for the practical utilization and even for the permanent custodial preservation of statistical war records produced by temporary services which have been or are being disbanded.

But the point of special significance is that practically every inquiry proposed by the government during the war required a statistical answer, and it may be noted incidentally that the science of statistics in fact had its origin in the effort to supply governments with an accurate valuation of resources for waging war. If a statistician may be permitted to say so the simple fact is that economists who engaged in war work seemed to become for the time being statisticians; and economics to become for the time being statistics. Under stress of the war emergency it put away traditional hypotheses, personal philosophies, ethical speculations, and abstract theories, and went out into the hedges and byways to find out things by way of rendering real social service.

Now a quite similar sort of service is just as essential in peace time as in war time. In peace time, as well as in war time, we must mobilize our resources for the achievement of social ends. We must be continuously mobilizing for peace with the end in view to insure in the highest degree our social wellbeing, and in mobilizing for peace, as in mobilizing for war, the inquiries proposed by the government and by agencies of social amelioration are generally inquiries requiring statistical answers.

Under normal peace-time conditions, it may be noted, the work being done by those classified in the government service as economists is, as it has been during the war emergency period, very largely statistical. Official economists are regularly engaged in the conduct of extensive and intensive statistical researches, gathering data by the use of schedules.

Are, then, economists so engaged only undertaking to help out in a field of scientific research which is admittedly short-handed, or is this sort of service strictly economic?

Not infrequently statisticians themselves express the opinion that statistics is in fact not really a science at all. It is, as they conceive it, merely a method, and the statistician is merely a technician who may hire out to do statistical chores in any field indifferently. The economist may of course in any emergency, such as the occurrence of war, do his own statistical chores, but it seems to be assumed that he will perhaps generally prefer to hire them done for him. So of the sociologist and of all other scientific workers, it is assumed that they will each and all on occasion probably want to employ statisticians to do compilation work under direction. In the field of scientific research, it would seem that the statistician cannot operate independently on his own. He must hire out to somebody.

Is then statistics merely a void technique or, if one will, a void formal science on the one hand,—or does the technique or science of statistics embrace a content of data? In the one case the statistician is professionally interested and skilled in the technique and theory of compilation only, and in the other he is professionally interested primarily in the substance, interpretation, and significance of his compilations.

By common usage there would seem to be at least four fairly well differentiated or differentiable concepts as to what statistics are, or what it, if we use the term in the singular, is:

1. Statistics are compiled numerical data of all sorts.
2. Statistics is a method or technique of compiling numerical data of all sorts.
3. Statistics is a formal science of the method or technique of compiling numerical data of all sorts.
4. Statistics is a social science, with a method or technique of its own, a defined field of operation, and a cumulative fund of systematized data or knowledge relating specifically to social conditions and phenomena.

The first of these concepts identifies statistics with figures and tables and that sort of thing indifferently in any field. It is a world-almanac concept. The second and third concepts give to statistics, as a method or technique or science of compilation, a free range in the field of scientific research, but they do not comprehend the data upon which the statistician operates professionally in compiling them into tables. It is not the world-almanac itself, but the method or technique or science of compiling almanacs, that is here proposed as the subject of statistical interest and labor. The fourth concept comprehends the data with the method or technique of compilation, but restricts the range of professionally statistical research to social conditions and phenomena, which is traditionally the special field or preserve of statistical inquiry.

One may perhaps assume that the world-almanac idea of what statistics are will not satisfy the statistician's sophisticated sense as a

definition of his profession, and that he will not write himself down as a mere compiler of the odds and ends of numerical data without rhyme or reason. He will not resign every source of inspiration for work. If he does not pretend to the lofty ideals of a professed science, he will at least pretend to the humble skill of an artisan who has mastered the simple technique of a lowly craft.

Passing on then to the second concept, obviously we cannot say "statistics or statistical data are a method or technique," and when we say "statistics is a method or technique," we clearly oust the data of statistics entirely from our concept, and imply that this mode or art of compilation, separate and distinct from the data compiled, is what we mean by statistics. If we did not mean this we should say, "statistics has—not is—a method or technique."

In this sense statistics is a way or manner or process of doing something. Probably in general what is implied is that it is a way of compiling numerical data, and specifically one way of doing, for example, economics or sociology or politics or biology or astronomy. That is to say, the statistical way of doing each and all of these sciences —one of several ways of doing each of them.

Statistics and statisticians are conceived to be in the service particularly of the social sciences. Statisticians may of course render service also in the biological and the physical sciences, but primarily and properly they ply their skilled trade of compiling data in the social sciences, because these sciences more than any other are dependent upon statistical compilations for the establishment of their basic hypotheses, and for the final verification of their speculative conclusions—or it may be in specific cases, as it has been frequently, for the disestablishment of fictitious hypotheses, and the demolition of false conclusions. In this humble capacity the statistician under close supervision fetches ballast of data for the social sciences, which are naturally speculative and naturally tend to rise into the ethereal regions where the danger of sudden burstings and rapid descents becomes imminent.

Thus the venerable mother of all the social sciences,—for statistics is the mother of the social sciences—is degraded to the position of a menial servant.

Mere compilation of data is in itself, when divorced from the function of interpretation, a very elementary sort of mathematics,—mostly addition and subtraction,—and the technique of compilation, also, is simple and easily mastered. Far less mathematics and technique is required for skilled compilation of data than is required, for example, by

the machinist in many branches of his trade. If the statistician's job is compilation of data of any sort for any one, he is not a very high grade or very skilled artisan, and he clearly cannot rank in the fellowship of economists or politicists or sociologists, except as a sort of handy-boy in the splendid halls and palaces of the social sciences.

This conception of the statistician as a technician is quite consistent, it must be conceded, not only with the idea of purely technical service throughout the broad field of scientific research, but also with the idea which has been in times past rather prevalent in government offices engaged in statistical work. Not uncommonly those administering these offices have felt that a college education, for example, was quite superfluous for a statistician. As they conceived him the statistician was a technician, expert in working out tabulation fields for punching cards, expert in manipulating various types of punching, sorting, tabulating, and calculating machines, expert in reading his own tables into text, and in filling in blanks in standardized texts, preserved inviolate from decade to decade, or from year to year.

For this sort of work, essential as it is, a college education or any very protracted apprenticeship does indeed seem superfluous.

If now the statistician rejects this humble rôle of skilled artisan working under direction, if he pretends to something more than mere expertness as a technician,—if, in a word, he pretends to a separate and distinct science, is the subject matter of that science the method, technique, and mathematics of compilation, including of course, the mathematical determination of correlations, margins of error, interpolations, probable deviations, dispersions, and miscellaneous averages, indices, and rates?

There is here at least something that has altogether the aspect of being scientific, and any one who reads our own and foreign statistical journals, and the various systematic treatises dealing with the mathematical processes of statistical work, will concede that the statistician must, if he is to understand some of the literature of his science, be a fairly good mathematician. Unquestionably he must be able to use, if not himself to develop, mathematical formulas to the extent that may be required in the particular line of statistical work in which he is engaged, and this may mean very considerable expertness as a mathematician.

Mathematics is a universal language in which science expresses itself wherever this language is required to give precision to scientific statements, and the statistician uses this language as he has occasion to use it, just as every other scientific worker uses it, that is to say, as a language for giving precise expression to the conclusions of statistical

research. But in and of itself the purely formal science of statistical compilation and interpretation is applied mathematics, and those who devote themselves entirely to it are essentially mathematicians rather than statisticians.

Practical statisticians know, moreover, that however interesting the mathematical manipulation of data may be in itself as mathematics, data in the raw mass as they come to the statistician are not generally susceptible of any considerable amount of mathematical refinement. Over-refinement of data is professionally recognized as a statistical vice, since it implies accuracy and simplicity in data to a degree which is unwarranted.

Defined as a formal science without specific content of data, statistics seems in fact to assume by definition a rather fictitious character. In the first place, the statistician is made to profess a science which does not comprehend the substance and data of his compilations, and, it may even be said, of his natural professional interests. Secondly, this science of compilation is not really his but the mathematician's, and in it the mathematician is professionally much more expert than the statistician himself. Finally, in the common mine-run of practical statistical work, this science of compilation even in very important lines of statistical research is in itself a poor thing, mostly addition and subtraction, and is not, except in some of its rather ornamental and attenuated refinements as a differentiated branch of mathematics, of a character which justifies its designation as a separate science.

As a professed master of this quite diminutive and ignoble science, it is true again that the statistician may sell his services in the open market to do compilation work in any field, but the chances are that his pretensions to a defined science will not be generally recognized as valid. As a compiler of data for the biologist, he will be for all his professions accepted as merely an artisan, practicing the simple technique of his trade in the field of biology. Probably, if the biological data require any considerable amount of mathematical refinement, the biologist will employ not a statistician but a mathematician. And he will be quite right in doing so.

It is to be noted that the statistician entering any foreign field,—that is to say, any field outside the range of social phenomena,—can carry with him only a very simple technique and rather elementary rules of procedure. He may take with him also the paraphernalia of his trade, card punching, sorting, tabulating devices, adding machines, slide rules, and calculating machines. This he does in his character as an artisan working with a more or less elaborate kit of tools and some degree of technical skill.

It will be freely admitted by statisticians that occasionally the statistician himself, for the precise interpretation of his data, must seek aid of the mathematician, who understands better than the statistician commonly does the harmonics and intricacies of mathematical calculations. And clearly the statistician who does seek such help must be presumed to be interested professionally in the substance and data of his compilations. Otherwise he will be in the position of employing a mathematician to render precisely that service which he himself professes to render, and his pretense to a science will become perfectly transparent and hypocritical.

What then is the statistician professionally interested in? The answer is that his interests lie clearly in the field of social phenomena. In this field statistics as a science originated in the service of princes and principalities; in this field it has rendered continuous service during the past centuries; and in this field it is today rendering service, extending the scope of its researches to embrace every phase of social life, direction, and conduct. This is the traditional field occupied by statistics down through the ages from its remotest origins as an administrative political science, the science of things worth knowing about the state, and developed in subsequent periods as the science of the *Goettliche ordnung* of human affairs, the *Physique Sociale* of Quetelet, the *Political Arithmetic* of Petty, and, finally, as the rounded out science of quantitative valuation of social phenomena.

The term science defines itself. It is knowledge, or as the dictionary puts it, "knowledge of principles or facts; accumulated and accepted knowledge which has been systematized and formulated with reference to the discovery of general truths or the operation of general laws; knowledge classified and made available in work, life, or the search for truth; comprehensive, profound, or philosophical knowledge."

Could any statistician devise a definition which would more certainly embrace in all of its aspects the accumulated and accumulating fund of compiled statistical data relating to social phenomena? Here certainly is a fund of "accumulated and accepted knowledge which has been systematized and formulated with reference to the discovery of general truths or the operation of general laws; knowledge classified, and made available in work, life, or the search for truth"—and the statistician may well emphasize in this definition the word "life." Statistics is knowledge systematized and made available for *life*, not primarily as raw material for the development of some other science, social or natural.

One essential characteristic of any true science is such a fund of

established, universally accepted truths, representing in the mass the actual achievement to date of scientific workers in the given field. Statistics as a social science has this prime characteristic of a true science in a preëminent degree, far surpassing every other social science in this respect of an accumulating fund of systematized knowledge.

"A science," according to Jevons, "teaches us to know, and an art to do, and all the more perfect sciences lead to the creation of corresponding useful arts." Does statistics lead to any useful art or arts?

There is, of course, an art of compiling data, and this art may be conceived to have its origin in the science of statistics; but the art of compiling data is one of the most insignificant of the arts to which statistics leads.

Perhaps the supreme art mothered by statistics is the art of government. One must, however, add to this supreme statistical art all the specialized arts of social conduct, and amelioration—such as those occupied with philanthropy, social hygiene, and education. Not that statistics is the only science back of these several arts of social direction, conduct, and amelioration, but it is traditionally and essentially the primal science of these arts.

Legislation, philanthropy, and every program of social amelioration must take account of actual conditions and tendencies as collective aggregates, and statistics must provide the essential data for every such program, because the collective mass tendencies in social life cannot be uncovered except as they are given statistical measurement, statement, and valuation. Statistics as a social science stands this test of fostering useful arts also excellently well.

Statisticians accept freely the idea of service, and of service especially in the field of the social sciences. They must insist, however, that they render this service not as servants but as masters,—not as either servants or masters of economists or sociologists, but as masters of their own independent procedure and selection in the field of social research. The economist may properly present certain of his problems to the statistician for solution; as may also the statesman, or the expert in social hygiene, or the philanthropist. The prohibitionist may submit to the statistician the problem of determining certain of the social effects of drinking and of prohibition, and the Life Extension Institute may submit its problems. But the ultimate source of the statistician's problems is not economic science, or sociology, or the league to extend prohibition, or an institute to extend life itself, or any program of social amelioration. The ultimate source of the statisti-

cian's problems is the living, growing, changing, complex thing which we call society.

Historically, economics, politics, and sociology have been defined within the field of statistical research as originally conceived. Social sciences by virtue of the fact that they are social rather than natural, deal with aggregates of units and collective or composite dynamic tendencies or forces. They deal with mass effects,—with classes rather than with units or individuals, and every statement regarding a collective aggregate assumes compiled data.

Statistics presents compiled data relating to the production, distribution, exchange, and accumulation of wealth; it relates wealth accumulation to population increase, wealth production to rates of wages and other incomes, volume of credit to price fluctuations. It determines rates of criminality, insanity, and defectiveness for different classes, and thus measures the vital powers of resistance to degeneration and disintegration,—resistance, that is to say, of the individual, regarded as a unit in a collective aggregate, or of the institution of the family, or of some other social institution, in the selective struggle for survival. It measures the breeding power of the race, or stock, or class, against the mortality rate in such detail as may be significant, developing accurate and concise statements of tendencies, out of comparisons of present with past conditions. It measures accurately, and determines the direction of those obscure, insidious, hidden, and involved social tendencies which in the mass determine social evolution or devolution. With these data in hand the economist or the sociologist has a sure foundation of ascertained and demonstrated fact upon which to establish his speculative philosophy.

The statistician cannot perform a similar service for the natural or physical sciences, because these sciences do not deal with collective aggregates except incidentally. In chemistry or physics, and in fact throughout the range of the natural sciences, a single demonstration is frequently sufficient and final. Social laws and tendencies do not present to the scientific investigator that immutability, simplicity, persistence, and finality, which characterizes natural and biological laws. In the field of social phenomena demonstrations must be continuous or periodical. They can never be regarded as final, and all the terms of the social sciences are collective, that is to say statistical aggregates.

In dealing with social phenomena and conditions the statistician must be a free agent. In dealing, for example, with economic phenomena he is not working as an economist, utilizing the statistical

method to develop economic science. He is regarding economic phenomena in all their complexity as presenting a field for independent statistical research. In this field he finds a fund of compiled statistical data relating to past conditions and tendencies, and each year new data are compiled and related to the data brought forward from past periods. The precise measurement of economic tendencies is thus extended, and every calculation is reworked to comprehend a new period.

Similarly throughout the field of social phenomena, the statistician works independently, and unbiassed by any speculative philosophy. Any given statistical induction may be of interest in one of its aspects to the economist, but it may at the same time in other of its aspects be of interest also to others—to the sociologist, the politician, the statesman, the lawyer, the doctor, the merchant, the philanthropist, to organizations of labor or of employers, and to various advocates of social reform and amelioration.

Wherever quantitative valuation is of significance in dealing with social aggregates, the statistician finds his proper employment. Statistics comprehends in all of its varied aspects the precise quantitative measurement, valuation and analysis of social life, and the accumulated results of such measurement, valuation, and analysis continuously carried on from day to day, from year to year, from decade to decade, and from century to century. Every new valuation acquires significance only in proportion as it is related to every similar valuation in the past, and in general with every other quantitative valuation of the past or present with which it may fairly be correlated. Statistics deals with absolute numbers primarily, but always with the end in view of determining tendencies and relativities.

In all of this work the prime characteristic of the statistician is that he has no hypothesis to prove nor any speculative philosophy to develop or validate. He is professionally indifferent to every sort of social propaganda, creed, doctrine, policy, theory, or opinion, and devoted singly to the development of statistical laws expressed as rates, incidences, distributions, averages, frequencies, and correlations, as determined by scientific compilation, refinement, and interpretation of data. By this process the statistician is enabled to forecast the future as regards social trends.

Properly and in character the statistician undertakes the interpretation of his data,—not a partial, but a complete interpretation. He may not be estopped from making an induction by the fact that the induction may have economic or sociological or political significance. All interpretations, even the most elementary, are bound to have

some such significance, and certainly some interpretation of his data must be conceded to the statistician. That an induction happens to be significant is in fact a most excellent reason for making it. The statistician cannot fairly be restricted to the insignificant, simple, and obvious first differences,—to the barren, unrelated first results of his additions and subtractions.

Complete statistical interpretation of data does not, however, comprehend any speculative, ethical, or philosophical elements, since statistical data are in themselves purely quantitative statements, and do not carry any philosophical or ethical or speculative content. There is no "ought" or personality to statistical induction or analysis. The statistician does not pretend to incorporate within his science philosophies not inherent in it but imposed upon it, but he may fairly insist that statistical inductions themselves to their uttermost completeness, extending into every field of social research, are the natural organic developments of statistical science. Statistics does not embrace socialism, because the socialist happens to use some statistics as a basis for developing his peculiar philosophy, nor on the other hand are the statistical inductions which happen to be of interest to the socialist any the less purely statistical on that account. While statistical inductions are philosophically neutral, being in themselves neither conservative nor radical, neither individualistic nor socialistic, they must be nevertheless precisely and completely determined, and made available as the data of all real social science and of all social philosophy.

Purely hypothetical systems of reasoning may very well serve a real scientific end in a primitive stage of scientific development. Such systems have undoubtedly, for example, facilitated the primitive development of economics, but in proportion as data become available the economist is bound to undertake something more than the development of flawless trains of reasoning, originating in purely hypothetical assumptions and terminating therefore in conclusions of doubtful real significance. He is bound rather to undertake to explain economic phenomena in all their baffling complexity, to develop every conclusion from data, and to eliminate everything in the nature of a hypothesis.

So of other social sciences, it is true that they must all gradually abandon primitive speculations in the process of substituting data for hypotheses. It is admittedly much more difficult to develop a living science than it is to perfect a dead system of logic, but inevitably a social science which remains hypothetical, however flawless and perfect it may be, tends to become an inert, closed, rigid, uninspired system.

In the broad field of social research, it may be noted the vital prob-

lems have generally been precisely those implied in the traditional "ifs," which have been passed on from generation to generation,—such for example as the very large "if" implied in Malthusianism. Statistics would substitute data for these "ifs," not data in the raw, but data compiled, analyzed, interpreted. For every "if" it would substitute the final and ultimate statistical induction—not any philosophy, or doctrine, or ethics, or speculation imposed upon the data, but the very quintessence of the data, the pure, statistical, socially significant distillation of the data.

Every science has undergone or is undergoing this sort of sea-change from something strange into something real. The age of astrology and alchemy passes for all sciences, although no science easily frees itself entirely from its halo of hypotheses and mysticism. Psychology has developed out of painstaking and persistent experimentation, observation, and self-analysis, but it is still more or less involved in mystical speculations regarding the super-ego, the power of telepathy, our astral bodies, spiritism, levitations, and other strange phenomena which the science cannot comprehend or even concede to be real. So in other lines of scientific research, even today as has been true in the past, at a given point speculation supersedes science. In the social sciences, as in other sciences, speculation tends to supersede science at some point, and it must be added that at this point dissention and contention begin, because there is beyond the confines of science no sure foundation for reasoning or philosophy or ethics.

It is perhaps worth noting that stupendous errors have been committed in the development of social policies, philosophies, and speculations by the disassociation of scientific conclusions from the data upon which those conclusions have been based, by the specious substitution of social for natural or particular terms, or by the assumption that conclusions hypothetically or historically true are true absolutely for all time. War, for example, is proposed as a selective struggle and militarism thus becomes a natural political order. Again, because some forms of government are or have been evil, and the exercise of some powers by any form of government is or may be oppressive, the doctrine of *laissez faire* is developed, and government itself is declared to be essentially evil. Or again, poverty is declared to be a natural phenomenon because "if" population tends to increase faster than the food supply poverty is clearly inevitable. From period to period one or another falsely grounded or superannuated social philosophy has exerted its hypnotic spell over whole communities, seeming to tolerate, turn and turn about, now this and now that sort of social evil, and even

to impose as a social duty the commission of certain outrages which a later age frankly condemns. In the field of social phenomena the hypnotic spell of false generalizations developed into social philosophies, policies, and ethics, has on occasion even tended to paralyze and render impotent organized agencies of social betterment.

Science itself does not commit blunders of this sort, but they are committed in the name of science, and particularly of primitive social science.

For these hypotheses and speculations especially, which have been or may be the occasion of blundering and misleading and contention in the field of social phenomena and conduct, statistics would substitute statistical inductions. It is the statistician's function to measure social tendencies precisely, not to reason or philosophize about hypothetical tendencies. It is his function to determine precisely rates and frequencies and correlations and probabilities in so far as these can be uncovered in collective social aggregates. This mass of living data which comprehends the future with the present and the past, this quantitative summing-up and statement of social phenomena and of social values constitutes the science of statistics. Skill and technique are means to an end in statistical work as in every branch of science and art. They are not in themselves ends, and will not serve to guide the statistician in electing the right course. He must bring to his work all the resources and guidance of a rounded-out science, which sums up past achievements, prescribes its peculiar technique, and gives direction to present endeavor.

THE ANALYSIS OF A CENSUS

By G. H. Knibbs, *Federal Statistician of Australia*

1. *General.*—At the present time the results of a census are usually published in the form of a series of tables, with some measure of analysis and interpretation in the form of comment. To a limited extent also, derivative results such as life-tables are sometimes given. But every competent statistician realizes that this is very far from furnishing any adequate idea of the real significance of the data, so laboriously acquired, and necessarily at considerable public expense. Hence the question naturally arises: "What ought to be the form of presentation of the results of future censuses?" This is the question I now propose to discuss.

Precedents already exist for doing much more than what is above suggested. The five professional papers published, for example, in connection with the United States Coast and Geodetic Survey are instances of the kind of thing which might well be done in connection with a census. The work itself in this survey consists of the measurement of base-lines, and of the angles of a network of triangles covering the whole area surveyed, together with the associated astronomical, chronometric and metrological work. This involves researches into the geometry of the earth's figure, into physics and geophysics, into practical astronomy, into the reduction of observations, into optical questions, into the measurement of the force of gravity, and so on. Indeed, one might quite properly say that the mathematical and physical sciences are all called into requisition for the purpose of the survey, and the researches cover a correspondingly wide range.

These researches are published (as already said) in professional papers, constituting not merely the appendix to the formal report, but often its most valuable element. Anyone acquainted with them realizes their value and the wisdom and public utility of the practice.

One might well say that a survey of the human beings occupying any territory is of at least as high on order of importance as the survey of the area which they occupy. Indeed the necessity of such a survey will emerge as soon as anyone attends to the facts; for indeed it must be self-evident that anything short of such a survey will not meet the inherent needs of the case. "The proper study of mankind is Man"; not merely in himself and in relation to his fellows, but also in relation to facts relevant to his well-being on the earth.

In this connection moreover it may be said that our ordinary statistical conceptions are not adequate. We think readily of "averages" but not of "distributions" about average values. The Belgian Astronomer-Mathematician Quetelet laid a foundation,—now quite a considerable number of years ago. But his conceptions, valuable as they were, are only a beginning. The notion of an average has to be supplemented by that of the characteristic of a distribution about the average or mean. And this desideratum has given birth to a new science, viz., the general theory of statistics and statistical results. This theory involves questions of probability, of the mode in which group-numbers arise, of the way in which individually observed facts are grouped (or dispersed) about their mean value, the dispersion or "scatter" itself often being a matter of high importance.

This is not the only element which needs development. We may have adequate grounds for believing that two series of facts are mutually related, and we may require a numerical expression for the degree of relation (correlation). By means of an appropriate analysis this can be obtained: thus we have a theory of correlation, which has wide applications in the Mendelian theory of inheritance.

Or yet again we may have data which, properly examined, enable us to see the law running through a series of phenomena, for example, the frequency of marriage or birth in the case of persons of different pairs of ages, and so on. When we can subsume the whole of the phenomena in question under some definite conception, expressible either by means of an algebraic equation, or by means of a graph, we powerfully advance our knowledge.

2. *Analysis and What It Involves.*—What has been said sufficiently indicates the general point of view. Extensive researches have already been made in various fields. The well-known "Biometrika" contains numerous instances both of methodological technique and of analysis. Various papers by Bachelier, Borthkiewicz, Charlier, Davenport, Edgeworth, Lexis, Livi, Pearson, Tschuprow, Yule, Westergaard, Wicksell, and many others, have laid the foundations of a method of great analytical power and importance. And though a comprehensive work on the whole range of statistical methodology is still a desideratum, it would be possible now to construct it. Its creation, however, involves both mathematical knowledge and practical experience in the statistical field, and unfortunately there are but few men who possess both the experience and the necessary leisure. Is not this a work for governments, or worthy of a private benefaction?

The Report on the Australian Census of 1911 contained, in Vol. I, an Appendix entitled "The Mathematical Theory of Population, of its

Character and Fluctuations, and of the Factors which Influence Them." This work (by the author of the present paper)—appreciatively referred to, among others, by American authorities—aimed on the one hand at supplying some necessary elements of mathematical technique, for analyzing various aspects of vital phenomena, and on the other at interpreting material made available by the first Australian Census which had been carried out on uniform lines and by a central authority. It embraced two elements, one technical or methodological, the other interpretative. An examination of it will reveal how current statistical data, supplemented by data rendered available by means of a census, can be made to furnish answers to important questions concerning the increase and character of a population.

It is easy to see that the questionnaire of a census, and the statistical material collected during intercensal periods, must be properly correlated in order to obtain the maximum advantage therefrom. Thus a satisfactory analysis may be said to involve three elements, viz.:

(i) Mathematical technique and methodology generally;

(ii) Appropriate correlations of data; and

(iii) Insight as to the significance of results obtained or obtainable.

The last is the only one to which we need now refer, and it will suffice, for the purpose of illustration, to mention but few elements.

The most fundamental thing about population is its rate of increase. But this depends largely, not merely upon its constitution with respect to sex and age, but upon its food-supply, its economic condition generally, and its standard of living. The last is a powerful factor in altering the rate of possible increase.

We are concerned, however, not only with mere numerical or quantitative results, but also with qualitative; and thus anthropometric measurements which can throw light upon the physique or upon the intellectual ability of a people are of high value. And they are very far-reaching in their consequence. The expansion of races, the difficulties of sufficiently increasing food-supply, the qualitative changes accompanying increasing density of population, the desirability or otherwise of miscegenation; these are subjects in regard to which inquiries are of momentous importance.

On the side of social-economics also, the issues are of no less significance. How national or private wealth is best measured, what are the characteristics of its distribution, how far, if at all, it is desirable that its accumulation should be restricted, how far national services should be nationally controlled or provided for by private effort, how far the levelling up as between nation and nation should be promoted,—these are questions calling for the highest order of statis-

tical analysis, and are questions which may not be postponed without danger.

3. *Mathematics and Its Relation to Practical Results.*—There is a vulgar impression that a statistician is a mere tabulator of data, and that, when tabulations have been effected, the work of the statistician is at an end. As a matter of fact, however, his real work only then commences. And moreover even the tabulation of group-results needs to be directed by one who fully understands the significance of grouping, and what is essential to furnish accurate results in the case of critical facts, such, for example, as the age which corresponds to the highest frequency of marriage, birth, etc., the age of lowest mortality, and so on. But ignoring the last mentioned fact, we may note that crude statistical results are attained with considerable error, and one of the most important functions of the statistician is to eliminate this error as far as it is possible to do so. Thus, an acquaintance with the mathematical theory of error is an essential part of his professional equipment. This in its turn involves a knowledge of the characteristics of chance distributions, for these in many cases furnish a guide for the proper reduction of crude observations so as to furnish the best result obtainable from the imperfect data which come to hand. Again, to obtain the best results one may have to decide whether the crude data should be regarded as a chance-distribution at all, or whether the appropriate conception is that they are functionally related to the values of the variable age, say, in some other way. And this is by no means a simple question, it is one often involving a nice discrimination between points of view.

Again, we may have to ask ourselves exactly what it is that we are seeking to obtain? Is it—for example—that limit which would be attained with an infinitely large population (a sort of ideal result); or is it that which most simply represents a very limited one? And behind these questions lies the whole theory of the empirical representation of numerical facts. We substitute for the irregular results obtained regular ones which conform—if possible—to some readily expressible law. This subsumption of statistical facts under clear-cut conceptions is in conformity with the general method of science, and involves an appropriate command of mathematical theory.

We may take an illustration to make clear what is meant. Let us suppose that the age of most frequent nuptial child-birth is to be ascertained. In a small population the result may be prejudiced by irregularities in the data. Hence we first "smooth" them, getting rid of any zig-zag appearance of the results. Then, only, emerges the ideal curve to which the facts *tend to conform.* This is the essence of the

matter. But to "smooth" results we must know the significance of first, second, and higher differences, or in other words the essential character of the curve which we regard as appropriately representing in their generality the facts examined. We are then, and only then, in a position to indicate with any exactitude the age in question.

It is obvious that life or mortality tables must conform to the requirements indicated in respect of smoothness, and so on. It is, moreover, easy to see that any general scheme of insurance must be based on appropriately *adjusted* data, and results derived therefrom. We need not further labour the point, viz., that mathematical science renders eminently practical service; it is really an essential in the proper analysis, representation, and indeed interpretation also, of statistical results.

4. *Indications of the Range of Statistical Analysis.*—In the first number of "Metron," published at Rome, will be found an article on the "Theory of Large Population Aggregates"* showing the significance of the mere theory of increase of population, and that the increase ultimately becomes zero, viz., when, for any given condition of things, the limiting density of population has been reached. At the rate of population-increase which characterized the last century this would arrive at no very remote date, and in any case the world's future food-supply will soon become a question of the first order of importance. This fact alone will suffice to emphasize the need for the analysis of statistics, and the necessity for entrusting it to experts of appropriate training and powers.

An indication of statistical analyses already carried out may reveal more clearly the real range and importance of the subject.† Starting with sex-ratio, we need to know what is the norm or average at each age for the whole western world, the ratio at birth and generally, for still and live births both nuptial and ex-nuptial, for the first-born, and so on. These facts are of sociologic importance and have a bearing upon national eugenics. Next the birth-rate itself and its relation to the marriage rate require to be ascertained, and where a mixture of races exists, and unrestricted miscegenation is opposed to popular feeling, the relative birth-rate of races within the population becomes itself a matter of far-reaching significance. From the standpoint of national development and from that of national eugenics, the effective birth-rate, after the infantile period—with its special dangers—has passed, is essential. The children saved from infantile disaster are what make up the effective population; in other words, mere birth-rate is itself of but little moment: it is the residual or effective birth-

* By the author of this paper.

† In the Australian Census of 1911, by the author of this paper.

rate with which we are concerned. Thus, Australia and New Zealand, though they have not large birth-rates, are good examples because their residual rates are high: in short, as nations they do not bring children recklessly into existence, but when children do come into being there is an endeavour to save them.

The drift of conjugal frequency and its distribution according to age, as affecting the birth-rate, as well as the stability of society, the inimical effects, and frequency of divorce, constitute a branch of social statistics which will not be neglected by students of sociology, or governments interested in national well-being.

The relative (or absolute) numbers of husbands of a given age, marrying or living with wives of a given age, may be defined by what the writer has called a protogamic or a gamic surface. The contours of this surface disclose the full conjugal particulars according to pairs of ages at a glance.

For calculating the number of marriages likely to take place, we need a theory of what may be called the *conjugal potential* of a community, and of its variation with changes in their economic condition. The change of probability with differences in the numbers living at each age needs therefore to be considered. Despite the fact that world statistics at present do not afford sufficient data to determine very exactly the form of the function by means of which the influence of variations in the numbers of unmarried persons can be eliminated, a function of high probability has been developed and tabulated, so that the elimination can be effected and the number ascertained.*

In order to represent the birth-rates of two populations in such a way as to eliminate differences in their age-constitution, we must have recourse to *natality indexes*, constituted similarly to mortality indexes.

To ascertain the age representing the beginning and end of fertility we need very extended observations. For Australia it appears to be about as follows:

PROBABILITY OF NUPTIAL MATERNITY

Age.....	11	12	13	14	15	16	...	49	50
	0	0	.5?	.2?	.22	.41	...	.0088	.0033
Age.....	51	52	53	54	55	56	57	58	
	.0012	.0006	.0005	.0004	.0025	.0015	.0005	.00000	

Obviously, however, these numbers are not those of the ideal curve representing the fact as it would be were it not influenced in some way by limitations of the available data, by social tradition, etc.

* By the writer of this paper: see Appendix I, pp. 214–223.

To express the relative frequency of first births after different durations of marriage and for different ages of women we need also a surface, so that the coördinates are: x = ages of the women; y = the duration of marriage; and z = the frequency. This surface may be called the *nuptial protogenesic surface*, or the *surface of nuptial primiparity*. In the graph of this, the contour for zero is the *agenesic boundary*, and the region outside of this is the *agenesic region*, *i. e.* it represents the series of ages and durations of marriage which are characterized by sterility. The average interval between marriage and birth for women of a given age may be called the *protogenesic index* for the age in question, and for women of all ages, the *general protogenesic index*.

The insight which this index gives in regard to the Malthusian modification of the physiological condition is of great and obvious sociological importance. It may be mentioned that for reasons which it is not proposed to detail here, it is necessary also to compute what has been called "*the protogenesic quadratic index.*"* It may be mentioned that a correction to the calculated protogenesic index is necessary when the population is not constant.† Also the age of greatest fertility is not immediately given by the data, but requires correction for preceding cases of maternity. It is thus for Australia changed from: Age 18.8 and probability 0.483, to Age 19.0 and probability 0.517.

The preceding will afford some general idea of the nature of the analyses of some of the more simple elements which demand consideration. We shall now indicate some of the more complex cases.

5. *More Complex Elements Subject to Statistical Analysis.*—In dealing with statistics of fertility we are confronted with difficulties in regard to data. It has been shown elsewhere‡ that in statistics involving age and duration, where there are partially specified and wholly unspecified cases, these must be distributed according to the laws of probability, and that *unspecified cases follow a regular law*. When this has been done, then and only then can a satisfactory analysis be proceeded with. This being done for Australia it was found that the number of children at a confinement is a definite function of age, and that both for nuptial and ex-nuptial cases, the relative increase with age x up to about age thirty-six is sensibly given by the equation $B = 1 + 0.00065\ (x - 12)$ in which B represents the increase in the probability of a multiple birth; after that age the probability decreases again. Similarly the probability of triplets also increases with age, and is about 50 or 60 per cent greater in ex-nuptial than in nuptial

* By the author of this paper; see Appendix referred to pp. 272–274.
† *Ibid.*, pp. 274–275.
‡ *Ibid.*, p. 302.

cases. The probability of twins occurring twice is nearly identical with the occurrence of triplets. The phenomena of ex-nuptial fertility are not very different from those of nuptial except that the maximum occurs about three years later, and tends to be *relatively* greater than the proportion indicated by the maximum from twenty-five years of age onwards.

When the duration of marriage and the age of the mother at the birth are both taken into account, say the ages being the abscissae (x) and the durations of marriage the ordinates (y), the relative frequency being then represented by verticals (z), the surface so defined may be called the *genesic distribution* at maternity. Or if the ages at marriage of the mothers be substituted for the ages at the birth, the distribution may be called the *gamogenesic distribution*. Thus we may adopt either or both for practical purposes, the gamogenesic tables denoting the proportion of wives who, having married at a given age (x), have during a duration of marriage of y years, borne k children.

In the preceding results the age of the husband, etc., is ignored: when taken into account the results become much more complex. The graph of birth-rates, based upon the ages of husbands as abscissae and of wives as ordinates, give a surface which I have called digenesic.* The contours defining equal birth-rates are appropriately called *diisogenic contours* and any series of ages giving a particular birth-rate may be called the diisogenic ages for that rate. Such surfaces reveal the rapidity with which the effective virility of the husband diminishes with age, and also the effective impairment of the wife, and reveal remarkable differences between different peoples.† Similarly we may construct surfaces for multiple diisogeny.

We shall consider but one other case of complex statistics, viz., that relating to mortality. It has been shown‡ that prediction tables for the frequency of death within a given duration of time, say one year, for persons of a given age are true only for a very limited time indeed. There has recently been a remarkable increase in the probable duration of life for nearly all ages, so great indeed that by the time a "life-table" has been constructed, it is already "out of date." The probable result for a given year can be obtained by extrapolating past results. The curves are sensibly exponential, concave upwards, the probability of mortality, as above said, decreasing with time. The general results show that the diminution in mortality is more marked in the young than in the old, and that it is not identical for males and females. The factors in operation are probably the following:

* See Appendix referred to, p. 350.
† *Ibid.*, pp. 360–361.
‡ By the author of this paper, *Ibid.*, pp. 280–281.

(i) Evolution of the protective reaction between the organism and its environment.

(ii) Changes in the quantity, quality, and appropriateness of the food supply.

(iii) Changes due to the reaction of the organism to economic conditions in respect of its nutritional and neural apparatus.

(iv) Changes in personal and general hygiene, in therapeutics and surgery, in prevailing traditions which affect the vitality of an organism, etc.

I have shown that the facts of the variation of mortality with age suggest the following theory of its nature:

In virtue of its plasticity an organism is both vulnerable and recuperable. At birth the change of environment is inimical, the initial difficulty of adaption constituting the *natal "force of mortality."* This falls off very rapidly indeed, and constitutes what may be called the natal adaptative effort. The initial adaption being established in the course of the first few days, there follows what may be called the infantile adaptative effort covering, roughly, the first twelve months of life. The inimical forces are now greatly lessened, this period being characterised by the rapidly diminishing *infantile force of mortality.* The growing incapacity for adaptation gives rise to what may be called the *senile force of mortality,* which probably operates from the first. The pressure put upon the organism by social life, by the appearance of puberty, by the assertiveness of the reproductive forces, etc., constitute an inimical force, which vanishes with the termination of the reproductive period, and may be called the *genesic force of mortality.* The exhaustion and general dangers of reproduction also constitute for the female sex an inimical force which may be called the *gestate force of mortality.* There are also dangers of a casual nature, which may in their totality be called the *adventitious force of mortality.* General mortality is the sum of all these.

It is not proposed here to discuss the theory of an actuarial population, or the limitations of the Gompertz-Makeham-Laudi-and-Lazarus theory of mortality. It will suffice to observe that the whole position calls for revision by a competent mathematician.

Enough has been said to indicate that an ordinary population census can be made to tell a far more interesting, instructive, and valuable story than it does at present. It would be easy to multiply examples. To show for instance how the mortality-frequency according to age and sex for various diseases can be obtained, or, carrying the research into the fields of wealth and income, to show how a *plutoprosodic surface* can be made to exhibit the frequency with which particular

incomes are associated with particular amounts of wealth, and so on.

6. *Special Reasons for Analysis at the Present Time.*—Apart from the general importance of statistical analysis in connection with a census, there are quite special reasons why this should be regarded as of more than ordinary moment at the present time. To these reasons we shall now refer.

The widespread movement towards democracy, the assertion of the claims of labour, the challenge of the rights of merely inherited wealth, the financial consequences of the great war, the question of the issues between production for use and production for profit, the anonymity and personal irresponsibility of capital and its reactions on nationalism, the social obligations of all members of any community to the community itself, the rate at which Nature's accumulated resources are being exploited, the possibilities of development of the world's food supply, the general raising of the standards of living, the international advance in eugenics, and similar questions, all indicate the urgency of the task before all great nations. None can afford to neglect to take stock of its affairs, to study its social and economic drift, to forecast its rate of exploitation of its recognised or available resources, to consider how it is to meet the various contingencies of national life, etc. Attention to these matters is indeed a national stock-taking.

Collisions between nations may perhaps be inevitable, but if they can in any measure be avoided, the dictates of reason indicate that this avoidance must be founded upon an intelligent appreciation of the whole of the circumstances of the case, including its relations with other nations. If the economic folly of collision and consequent destruction in war is to be replaced by intelligent and amicable readjustments of national interests, the way lies in a better knowledge of the comparative positions of the affairs of each nation. That is the only "way out."

We are denizens of a world of limitations. Collision of interests may perhaps be ultimately unavoidable, and is certainly inevitable so long as egoism is universal. War and death-struggle may perhaps be involved by the very "nature of things." Or it may not. Be that as it may, one cannot resist the conviction that if one hundredth part of what is spent in war were applied to a study of the problem of solving the difficulties between nation and nation, we should avoid a vast amount of trouble, and approach a partial, if not a complete, solution of international and internecine difficulties.

The proper analysis of a census is a first step towards a really systematic and incisive study of national and world affairs. Without such an

analysis, conjecture, rather than knowledge, governs our thought and our action, and may lead us far astray. The powers at our disposal are becoming continually more terrible, and the "way of force" increasingly ruthless. One can assign no limit to the consequences of appeal thereto, and it may be taken for granted that the next struggle will be of a far more deadly character than that just ended. This surely must give us pause, and should lead all nations to appraise the real state of society, the meaning of individual, of communal and of national life.

There is, awakening in all thoughtful men, a feeling that we shall do well to ask ourselves the great question—"quo vadis". Whither is our civilization trending? What is to be expected if the universal appeal is to the power of inflicting injury?

One may well ask: "Are we in the throes of birth of a new era, and if so what will it witness?" Will it see the world marshalled in dread array in a ghastly appeal to the shrieking Bellona to call forth again the dogs of war, or will it witness a great endeavour to recognize that in that way lies irretrievable disaster and perhaps complete ruin. For be it remembered that we can command, as never before, the vast resources of our common mother Nature? It is not impossible that we may achieve even untold success in new instruments of destruction.

To these questions we may perhaps answer: "Destiny lies on the knees of the gods." Be it so, but we can survey its sway, perhaps can take an intelligent interest, not merely as fatalistic onlookers, but as intelligent coöperators. May it not be our privilege, as statisticians, to point the way in which the maximum safety lies over the uncharted seas of the future? Or if that be the function of the statesman, may we not furnish such a conspectus of international affairs, that the trend of Destiny shall be obvious, and the chart of the World Experience such that we can discern something of the Unknown into which we are continually passing?

I cannot believe that the leaders of intelligent nations will, in future, neglect to make available to all thoughtful men and women therein that survey of affairs which alone can guide our way. That way will either be appallingly stern, or will be gladdened by good fortune, according as the spirit of our decision sets right at defiance, or loyally recognizes it as the compass which must guide the barque of our world's life over the ocean of the future.

THE STATISTICAL METHOD IN PROBLEMS OF WATER SUPPLY QUALITY

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INTRODUCTORY

The concept of water supply quality has the simplicity of the unknown to the layman, but the complexity of the universe to the sanitarian. If one uses the mathematician's measure of the complexity of a function—the number of its attributes—the problem of water supply quality, a function dependent upon mutually active natural, physical, chemical and biological phenomena, offers an attractive field of study to the statistician. For the professional statistician has been concerned always with "quantitative data affected by a multiplicity of causes"[1] and with their elucidation. In considering the causes operating to produce relatively good or bad waters, such as rainfalls, pollution, purification, etc., and their interpretation upon the basis of laboratory findings and personal surveys it becomes manifest that problems of water supply quality fall well within the scope of statistical method. Just as in all statistical problems, so in that of water supply quality, the investigator is confronted with the two-fold task of determining the method of evaluating the units of interpretation and of defining the limiting values of such units. The method of approach to each problem involves a statistical viewpoint, as well as a quantitative methodology. The present paper has been prepared in order to illustrate, in as brief terms as possible, this statistical method of approach, by developing therein a few examples of its application to the question of water supply quality. The writer plans to trace the evolution of the concept of water supply quality in the sanitarian's mind and to point out in such a development the function which the statistical art has performed or may be expected to supply in the future. The discussion appears to be a necessary one since hitherto the water supply investigator has been accused of an aversion for the quantitative sciences, while, on the other hand, the professional statistician has shown a neglect of a field which perhaps did not appear to be worthy of his mettle. The present study may serve to remove this friendly distrust which retards in a degree progress in critical studies of water supply quality.

I. THE LABORATORY EXAMINATION OF WATER SUPPLIES

The sanitary quality of water supply must be predicated necessarily upon the demonstration of its relative inability to produce disease.

With the present germ theory of disease, such a demonstration resolves itself into the laboratory problem of enumerating the number and types of pathogenic organisms in stated quantities of water. It is apparent, therefore, that the technique in this instance is largely bacteriological, and the discussion, for purposes of simplicity, may be restricted to the problems of the evaluation of bacterial units, as illustrative of the statistical method.

It is manifestly impossible and impracticable to examine an unknown water in such manner as to determine its content of all kinds of bacteria or even of those relatively few classes of specific organisms which it is known are both disease-producing and capable of living in water. It is more desirable as well as convenient, therefore, to choose one family or group of micro-organisms whose natural habitat and life history are similar to the variety of pathogenic organisms and whose detection by laboratory methods is most simple and speedy. Bacteriologists have concluded that a particular class of bacteria serves as the most convenient index to water supply quality or contamination. They have chosen as this index class or type the so-called colon or bacillus coli group. The B. coli group has been so selected, because its origin is in general the colon or digestive tract of man and its presence is usually indicative of human sewage pollution (the possible and probable existence of colon types in other environments need not concern us at this point).

One of the primary objects of the bacteriologist, therefore, is to differentiate the bacterial species present in a water supply, so as to demonstrate the presence or absence of members of the B. coli group. In addition, it is necessary to obtain some idea of the relative frequency of such a group, since smaller numbers naturally connote a more remote pollution, due to the dying off of bacteria in the unfavorable environment of water, to the presence of antagonistic life, and to other natural and artificial barriers to its development. The problems arising in the laboratory differentiation of bacterial varieties offers, therefore, material for an initial example. Two general methods of distinguishing groups of bacteria are available. Both are based upon the method of differences. In the one case, morphological or structural characteristics, and in the other, metabolic distinctions control. Various classifications of the colon group, for instance, are based upon its ability to produce acid and gas from fermentable substances. Investigators have observed that certain types of B. coli ferment such complex organic compounds as sucrose, dulcitol and raffinose while others do not. Differences in the amount and character of gas formation from certain substances distinguish other types of bacteria.

In all classifications, however, it has been recognized that the same group may have a variety of reactions which overlap partially those of other groups. Two types of bacteria, for instance, may both ferment sucrose, but may differ in their effect upon a second or third compound. This gives rise naturally to a vast amount of possible combinations between characters and Levine[2] points out that "as the number of fermentable substances increases, the number of varieties increases geometrically approaching infinity. The number of 'varieties' is given by the formula 2^n where 'n' is the number of characters studied. Thus with 8 characters there are 256 possible combinations; this number rises to 1,024 with 10 characters and to 65,536 when 16 characters are observed. The absurdity of regarding each character as of similar and equal differential value is thus evident."

Levine, as well as other more recent investigators, has concluded that the principle of the correlation of characters should be emphasized in the attempt to distinguish bacterial species. He points out that certain properties have been universally accepted, after long checking, as reliable evidences of bacterial differences. Among such properties, he enumerates the selective dyeing of bacteria, their powers of spore formation, and their adaptation to aerobic or anaerobic development. The taxonomic value of the characters of motility, indol formation, and fermentation of certain compounds, on the other hand, he assumes to be still debatable. In order to avoid the adoption of a confusing classification of bacteria upon the basis of every character studied (of which we have indicated only a few) he has recourse to a basis of subdivision "on that character which gives the greatest amount of information as to the manner in which the resulting sub-groups react with respect to other characters."[2] By making use of the above principle Levine evolves a classification of coli-like bacteria which is based almost completely upon statistically evaluated correlated characters. For the purpose of this study, he recognizes two main strains of bacteria, the B. coli and the B. aerogenes-cloacae group, which earlier investigations have shown to be distinguishable most often by their reactions to methyl-red and to the Voges-Proskauer reagent. The first strain is usually methyl-red positive and Voges-Proskauer negative, while the second strain shows the reverse. The justification of this initial subdivision into two main groups consists in the fact that the strains thus subdivided show end products of carbohydrate fermentations of two entirely distinct kinds.

Levine's procedure consists in tabulating all of the reactions of the organisms studied in each of the above two groups in two different tables, from which are calculated the coefficients of correlation for each

pair of characters. He selects, then, for subdivision that character which gives the highest coefficient of correlation with the greatest number of other characters. For these resulting sub-groups new correlation tables are prepared and further subdivision is made. These sub-groups are regarded as species and each is assigned its name.

In order to illustrate Levine's use of the coefficient of correlation for taxonomic purposes, let us follow his procedure in the subdivision of the B. coli, or methy-red positive and Voges-Proskauer negative, group of bacteria. For the 182 strains of this group that were studied by means of microscopic and metabolic methods, the coefficients of correlation shown in Table I were obtained.

TABLE I.

COEFFICIENTS OF CORRELATION OBTAINED FROM PAIRS OF CHARACTERS AMONG 182 STRAINS OF THE B. COLI GROUP

	Motility	*Indol*	*Sucrose*	*Raffinose*	*Dulcitol*	*Glycerol*	*Salicin*
Motility		−.39	+.53	+.43	+.53	+.18	+.40
Indol	−.39		+.08	+.00	+.02	−.28	+.76
Sucrose	+.53	+.08		+.99	+.58	−.38	+.20
Raffinose	+.43	+.00	+.99		+.58	−.29	+.27
Dulcitol	+.53	+.02	+.58	+.58		−.21	+.60
Glycerol	+.18	−.28	−.38	−.29	−.21		+.52
Salicin	+.40	+.76	+.20	+.27	+.60	+.52	

Since Levine's criterion for the choice of a character for subdivision is that that character should give the highest coefficient of correlation with most other characters, it is apparent, from an inspection of Table I, that sucrose, raffinose, dulcitol, and salicin meet this criterion more completely than do other properties. For special technical reasons, Levine chooses sucrose for primary division of the B. coli group and obtains by differentiation on sucrose ninety-three strains of the sucrose positive and eighty-nine strains of the sucrose negative groups. These two groups combined form, of course, the total of 182 strains initially chosen for study. Further study of the sucrose positive strains discloses a series of coefficients of correlation of characters as shown in Table II.

TABLE II.

COEFFICIENTS OF CORRELATION FOR PAIRS OF CHARACTERS AMONG 93 SUCROSE POSITIVE STRAINS OF THE B. COLI GROUP

	Motility	*Indol*	*Dulcitol*	*Glycerol*	*Salicin*
Motility		−.27	+.67	+.40	+.54
Indol	−.27		+.05	−.42	+.28
Dulcitol	+.67	+.05		−.32	+.39
Glycerol	+.40	−.42	−.32		+.32
Salicin	+.54	+.28	+.39	+.32	

Table II indicates that motility is the best correlated character and this property provides, therefore, for two further sub-groups, a sucrose-positive motile sub-group and a sucrose-positive non-motile group. These sub-groups are treated in the manner already illustrated and the coefficient of correlation for different characters provide for further subdivision. With the aid of this statistical interpretation of his studies of 333 coli-like bacteria, isolated from various sources, Levine suggests a classification of bacterial varieties. The summary of this classification need not be repeated here, since the reader is interested more in his method of attack than in the resulting bacteriological findings.

Such classifications as Levine's supply the sanitarian with the qualitative information necessary for the interpretation of one phase of the water supply quality problem.* The analyst dealing with waters is concerned not only with the nature of the bacterial types present therein, but also in the magnitude of their content, since it is the latter which indicates the degree and the remoteness of pollution. In the search for a potable water, it is often useless to seek that water which has no possible source of contamination, but it is always necessary to determine the quantitative bacterial importance of the latter. The methods so far described answer only one question, that is, what types of bacteria are present in the water. In the solution of the second inquiry, regarding the number of a particular type in a stated quantity of water, statistical method has played recently an important part.

In the simpler tests for the B. coli group in waters, the so-called fermentation-tubes are used. These tubes contain the medium selected for most efficient differentiation of the B. coli group from other kinds of bacteria and are inoculated with specific quantities of the water to be tested. The production of gas in the tubes after stated periods of incubation indicates the presence of the B. coli group. Our knowledge that of five tubes, each inoculated with 0.1 c.c. of the water, four show the presence of the organism, is of value, but more important is the additional fact that such a series of findings indicates that the probable number of organisms in the sample tested is about 1,600 per 100 c.c. This conversion of qualitative fermentation-tube results into quantitative values is of special interest to the statistician.

In 1915, McCrady[3] showed that "the frequency of the appearance of the fermenting organism in the volume drawn from the sample for the test is an exponential function of the number of such organisms in the sample," and that "every fermentation-tube result, whether simple or compound, corresponds to one most probable number of organisms."

*The subdivisions Levine develops have their importance to the investigator in the fact that species or varieties appear to be somewhat correlated with habitat or source of pollution.

By employing the theory of probabilities, he demonstrates that, given the result "$\frac{p}{p+q}$ in 1 volume," for instance, the corresponding most probable number is given by the solution for x of the equation

$$1-\left(\frac{V-1}{V}\right)^x=\frac{p}{p+q}.$$

Thus, for the result "five out of ten tubes positive in 1 c.c.," the most probable number is given by solution of the equation $1-.99^x=5/10$, since $V=100$ c.c., assumed as the original quantity of water sampled. The equation being solved, $x=69$ or the most probable number of B. coli in the sample, per 100 c.c.

For compound results, such as $\frac{p}{p+q}$ in 10 c.c., $\frac{r}{r+s}$ in 1 c.c., a more complicated formula is employed which is built up, as follows:[3]

For the result $\frac{p}{p+q}$ in 10 c.c. the equation becomes $(p+q)$ (log .9) $=\frac{p\ (\log\ .9)}{1-.9^x}$ which is obtained by differentiating for a maximum the equation given in the earlier paragraph for the probability of the results.

If the result is $\frac{p}{p+q}$ in 10 c.c., $\frac{r}{r+s}$ in 1 c.c., the equation stands

$$(p+q)\ (\log\ .9)+(r+s)(\log\ .99)=\frac{p\ (\log\ .99)}{1-.9^x}+\frac{r\ (\log\ .99)}{1-.99^x}$$

where $(p+q)$ = number of tubes inoculated with 10 c.c. of sample
$(r+s)$ = number of tubes inoculated with 1 c.c. of sample
x = number of fermenting organisms in 100 c.c. of sample
p and r = number of tubes giving positive results in 10 and 1 c.c. respectively.

If lower additional quantities of water are tested, extra similar terms are added to each side of the above equation. This equation has been modified by Wolman and Weaver[4] into

$$100\ (p+q)+10(r+s)=\frac{100p}{1-.9^x}+\frac{10r}{1-.99^x}$$

since, approximately, log .9 = 10 log .99 = 100 log .999.

McCrady published later[5] a series of tables for the rapid interpretation of these results which makes the standardized use of the probable numbers of B. coli possible for the water supply investigator.*

*The assumption of McCrady that the distribution of B. coli is similar to that in a mixture of a few red balls with many white balls is to be contrasted with the hypothesis of other workers that bacteria are uniformly distributed in water (G. C. Whipple[12]). More recent independent investigators, however, confirm McCrady's assumptions.

The work of McCrady was followed by other investigations dealing with the numerical interpretations of B. coli tests, of which the more important are Stein[6], [7], [8], Greenwood and Yule[9], and Wells[10], [11], [12]. The results of Stein and Greenwood and Yule, although differing in technique and in additional interesting viewpoints, are in substantial agreement with those obtained by McCrady. Stein[8] adds considerable interesting statistical material to the B. coli problem by introducing the so-called B. coli factor method, in which he considers the most probable number of B. coli per c.c. from the percentage of positive tests, the expected error of results, the study of the distribution of coli during a series of tests, and the "coli characteristic" which attempts to show by one figure, the average coli, the expected error and the variable distribution.

The discussion of the problem by Greenwood and Yule[9] has all the intricacy and mathematical complexity usually associated with Yule's contributions. Their findings, however, agree with those of McCrady and Stein. Greenwood and Yule, for instance, give as their formula for the number of B. coli per c.c., when using several tubes with 1 c.c. each

$$x = \text{B. coli per c.c.} = 2.3 \log \frac{p+q}{q}$$

whereas McCrady gives for the same condition (using an original size sample of 1,000 c.c.)

$$x = \frac{\log \frac{q}{p+q}}{1{,}000 \log .999} = \frac{\log \frac{q}{p+q}}{-1{,}000(.0004344)} = \frac{\log \frac{q}{p+q}}{-.4344} = -2.3 \log \frac{q}{p+q}$$
$$= 2.3 \log \frac{p+q}{q}$$

Perhaps the mathematician's interest may be aroused to the sanitarian's problems of water supply by the mere examination of Greenwood and Yule's discussions, while the bacteriologist may view with some alarm the same paper. It should be postulated in either case, however, that superficial considerations should not prevent the mutual aid which these two branches of science may extend to each other. While such complexity of treatment of the numerical interpretation of fermentation-tube tests as is indicated by the formula

$$P = \frac{\int_o^k \left[e^{-ha_1 n_1} \left(1 - e^{-ha_1}\right)^{m_1} \cdot e^{-ha_2 n_2} \left(1 - e^{-ha_2}\right)^{m_2} \right.}{\int_o^w \left[e^{-ha_1 n_1} \left(1 - e^{-ha_1}\right)^{m_1} \cdot e^{-ha_2 n_2} \left(1 - e^{-ha_2}\right)^{m_2} \right.}$$
$$\left. \cdots e^{-ha_n n_n} \left(1 - e^{-ha_n}\right)^{m_n} \right] dh$$
$$\left. \cdots e^{-ha_n n_n} \left(1 - e^{-ha_n}\right)^{m_n} \right] dh$$

may attract the statistician, it is hoped that it may not at the same time deter the laboratory technician from the adoption of devices which provide for more adequate solutions of his problems. Emphasis must be placed upon the fact that the mental attitude resulting from the adoption of statistical method has much promise in a field of endeavor where laboratory findings are too infrequently tested for accuracy of interpretation and rarely treated as examples of mass phenomena. The work of such men as Stein and McCrady has done much to introduce such methods by clarifying our concepts of fermentation tube results and their relative significance.

That the statistical method is an important asset in the exposition of laboratory findings is illustrated in another series of studies of various phases of water supply. Whipple[13], for instance, has demonstrated that "if, in a series of daily observations of the number of bacteria in a filter effluent extending over a year the deviation of any determination from the mean should be found to be more than five times as much as the probable error, to use a round number, this should be rejected from the series as being, for some reason or other, abnormal." He has made important contributions to the study of the frequency distributions of measures of various bacteriological, biological, and chemical characteristics of water, such as the preliminary finding that extended series of filter effluent results follow definite statistical laws in their distribution. His conclusion has been further substantiated by the more recent study of Wolman[14] of thousands of laboratory findings, in which it is indicated that the logarithms of bacterial counts, through long periods of time, have the characteristic normal probability distribution of more familiar biological statistical data.

It is of considerable interest to refer at this point to a form of graph presentation of data developed by a sanitary engineer which may be unfamiliar to most statisticians. Allen Hazen[15] in 1914 devised a form of chart ruled with a horizontal scale so divided that the curve of probability would plot thereon as a straight line. Any series of observations, therefore, which varied in accordance with the probability law would plot also as a straight line. Illustrations of the use of such paper in water supply problems may be found in the original paper of Hazen[15] and in subsequent discussions by Whipple[13] and Wolman[14].

Stein[16], in his study of the bacterial count in water and sewage, has added considerable material to our conceptions of the variability of laboratory findings and their importance in practical studies. He has concluded, after an interesting detailed analysis of the problem, that:

(a) For platings of a single sample of water, the mean error is equal to the square root of the number of colonies on a single plate, or the square root of the average number of colonies on several plates.

(b) The variations to be expected for careful and accurate work with bacterial counts are indicated by:

(1) Standard Deviation of ± 12%

(2) Deviation (1 in 10 times) of ± 25%

For ordinary routine work:

(1) Standard Deviation of ± 25%

(2) Deviation (1 in 10 times) of ± 50%

His comparison of the characteristics of bacteriological data with certain mathematical series should be of interest to the reader, since he shows, for example, that for daily tests of Lake Erie water for one month the Lexian Ratio is 29.00 and the Disturbancy Coefficient 124.00, while the corresponding values for a normal mathematical series (Bernouilli) are given as 1.00 and 0.00 respectively.

II. THE INTERPRETATION OF THE QUALITY OF WATER SUPPLIES

In preceding paragraphs the writer has indicated a few of the problems encountered in the laboratory technique of water supply examination, which lend themselves to statistical treatment. It has been impossible to include in the present brief paper any complete survey of such applications to other phases of laboratory procedure, but sufficient material has been presented, to demonstrate that the data in the field of laboratory technique have considerable to offer to the professional statistician as bases for the development of interpretative principles of quality.

The writer believes that some mention should be made briefly of certain interesting possibilities of development in the application of statistical method to general problems of laboratory procedure. The use of the coefficient of partial correlation, for instance, does not appear to have been introduced widely in the interpretation of laboratory findings, yet the necessity for its application is most apparent. Often investigative work in water supplies is carried out on a large or plant scale with the aid of analytical laboratory methods. In the study of the chlorination of a water supply, for example, a number of different variable quantities such as turbidity, color, organic content, and bacterial densities have their effect in modifying the efficiency of the disinfection process. In practically all conclusions from such studies no attempt is made to determine mathematically the effect of such variables, other than by mere inspection of tabulated data. There is little doubt that erroneous conclusions are often obtained through the failure to evaluate quantitatively the importance of fluctuations in the various characteristics of waters subject to chlorination. It is almost impossible to determine by qualitative inspection of a series of daily observations, over an entire year, of temperature, turbidity, color, organic

content, and bacterial density in a water supply, whether the effect of a constant dosage of chlorine is influenced more greatly by any one of the above characteristics or by a combination of several or all of them.

The same problem arises, of course, in the study of any of the phenomena associated with the purification of water supplies. In the coagulation of suspended matter in water, for instance, all the variables such as time, agitation, temperature, hydrogen-ion concentration, nature of suspended matter, and character of coagulant play an interconnected part. The principle of partial correlation could be adapted with profit to these problems of associated phenomena.

The application of such a statistical principle as pointed out above is complicated, however, by the fact that the more simple statistical coefficients usually cannot be directly applied to the problems encountered, on account of the fact that such measures presuppose the use of data having a symmetrical or Gaussian distribution, while the phenomena with which the sanitarian has to deal often are characterized by asymmetrical distributions.[17], [18]

Michael[18] has discussed in this connection the determination of the most probable number of bacteria present in a sample and has demonstrated that it is not permissible to apply the probable error in the usual manner on account of the fact that the logarithms of the plate counts, and not the counts themselves, show a Gaussian frequency distribution[19]. McEwen and Michael[17] in another field of investigation have been confronted with the same problem of determining the "functional relation of one variable to each of a number of correlated variables" where such variables do not show the usual symmetrical frequency distribution. It is manifestly impossible to extend in this paper the elucidation of these applications of statistical method to problems of laboratory and plant, but the reader may find profitable data in the original papers already noted.

The opportunity for the application of statistical tests to problems of water supply quality is not restricted, however, to the materials of the analyst. The consideration of the potability of a supply involves always a series of mutually active attributes, each of which has its importance in determining the character of the water. The concept of quality connotes, therefore, a composite of properly weighted individual and fundamental units, in the evaluation of which statistics again comes to the fore.

It is unfortunate, however, that in the field of interpretation of quality statistical method has been even slower of application than in the corresponding study of laboratory data. The quantitative evaluation of sanitary data has always given way to the liberal exercise of

expert personal judgment. Where a multiplicity of causes predetermines a phenomenon, such as quality, it was thought that a proper perspective was possible only through the development of a maturity of judgment in which the play of the manifold effects was qualitatively summarized rather than quantitatively analyzed. As the methods of diagnosis of quality developed, however, the opportunity for the fruitful application of the principles of mass phenomena gradually becomes apparent. With this development of a new viewpoint, good as well as evil sometimes resulted. A complete swinging of the pendulum to the quantitative side of interpretation was feared, where the attempt was made to substitute for individual experience and judgment pseudo-quantitative measures of doubtful significance. Some of these efforts, in which statistical laws frequently were ignored, will be discussed later in this paper. In general, however, a realization is gradually coming over the sanitarian that statistics as a means, rather than as an end, has much to offer in the clarification of his problems. If the succeeding pages seem somewhat bare, in their statistical implication, the professional statistician should remember that the concepts there discussed mark the advance of a new light in sanitary engineering, which, though feeble in its flicker, gives promise of a greater brilliance in the not distant future.

Attempts to formulate water supply standards of composite character represented one of the earliest applications of semi-statistical method. Most of these were based upon the erroneous conclusion that methods of evaluating units had been standardized throughout the country. Attention has been called to this fallacy of endeavoring to establish limiting values of units attained by varying methods by Hinman[20], Norton[21], and Morse and Wolman[22]. Fundamental training in statistical interpretation no doubt would prevent the adoption of water supply quality standards before the principles of unit evaluation have been rigidly enforced.

It is not amiss, perhaps, to call attention at this point to the close analogy between the so-called scoring of a water supply, or the quantitative allocation of the quality upon the scale of sanitary safety, and the statistician's concept of index numbers. Wolman[14] has shown recently that the operations involved in making a price index number are similar to those followed, to a greater or less extent, by investigators of water supply scores. In the case of price index numbers, the object of weighing is to give each commodity included in the index number an influence upon the results corresponding to its commercial importance. In water supply index numbers, the object of weighing likewise is to give each factor making up the score an influence upon

the results corresponding to its sanitary importance. Although the problems in the two fields are the same, their solutions are necessarily different, since, in the case of water supply scores, the conversion to a common base of such units as bacterial results, sanitary surveys, operating efficiencies, etc., cannot be carried out because of the presence of varying personal opinion or judgment. It has been noted[14], however, that it still remains possible to make use nationally of simplified index numbers of water supply quality restricted in their range of significance and composed of similar units or, better still, of individual units, provided the method of evaluation of such units has been definitely and completely fixed.

Interpretations of the quality of a water include frequently more than a summary of the structural and environmental features of the supply. The possibilities of the intelligent and fruitful application of statistical devices, such as the coefficients of correlation and of variation, to other phases of water supply are mentioned only briefly here, since their complete discussion would involve a paper of a far too great length. Whipple* for instance, has suggested the use of the coefficient of correlation in analyzing the vital statistics of cities which have made changes from poor to good quality water supplies, in order to demonstrate quantitatively the existence of the Mills-Reincke phenomenon. Hazen[15] has made excellent use of statistical method in his analysis of the storage provided in an impounding reservoir on any stream and the quantity of water which can be supplied continuously by it. He introduces the coefficient of variation as a measure of the degree of variation in flows of different streams and by its further use has found it possible to get an approximate expression for the storage required to carry the surplus water of wet years over to dry years, which expression, in general terms, applied equally well to streams in different localities. In addition, he describes methods of estimating the probable errors in the results obtained and makes the important comment that "frank recognition of the large probable errors in many of the results cannot fail to be advantageous."[15]

The opportunities for further application of similar methods have appeared in the present writer's studies of the correlation of bacterial contents in water supplies with rainfalls upon stream watersheds and with hygienic resultants of inferior quality such as typhoid fever and diarrhoeal diseases. In these particular studies, the statistician could contribute excellent aid, since the writer is not aware of an effective method of comparing correlated phenomena in which one series of characteristics is continuous, while another is discontinuous. In addi-

* Personal communication.

tion, quantitative variations in magnitude of the values in both series are not of paramount importance, but the direction of such variations is the interesting event. The coefficient of concurrent deviations in this instance, does not appear to supply all the desiderata. An example may make our problem clearer. In the study of the daily tap water analyses of a city water supply, we find, by inspection, that the B. coli contents rise after rains on the watershed of the stream supplying the town. It is also found that such rises are masked, to varying degrees, by purification processes and by the efficiency of operation of such processes. If changes in method and efficiency of purification are brought about and the qualitative reflection of rainfalls in resultant B. coli density in tap waters is modified, how can we measure quantitatively the change in sensitiveness of tap water quality to rainfall from month to month? The data at hand for this purpose, reduced to simplest terms, are in each month B. coli values for each day (continuous series), which differ in density from day to day, and rainfall records (discontinuous series) which may give a zero value for all the days but three or four during the month. If, during the month of July, the B. coli per 100 c.c. rose from 2 to 2,000 from July 7 to July 8, following a rain of 0.8 inch on the stream on July 7, and during August the B. coli per 100 c.c. showed no jumps above 5 in spite of a number of days of rainfall of about 0.8 inch, what should be the statistical relation between the months of July and August for these particular considerations?

This paper should not be concluded without some reference to the part that the study of purification processes has played in modifying and determining the quality of water supplies and the importance therein of the mathematician's tools. It is frequently the sanitarian's problem to include in his valuation of a water's safety some definite estimate, among other things, of the efficiency of operating features involved in the treatment of such a supply. This problem has given rise to various measures of treatment efficiencies, which only recently have been subjected to rigid statistical study. As an illustration of this type of measure the percentage removal of bacteria from untreated to treated waters has persisted. Statistical objections to this measure are well known to the reader and substitutes for this measure of performance, and indirectly of quality, have been much sought after. It was long recognized that the real measure of performance should include data regarding the distribution of the efficiencies over long periods and recommendations suggesting the classification of bacterial results according to frequency distributions have done much to clarify the interpretation of treatment figures.

Further development of the same problem of plant performance

along statistical lines has been made by Wolman[23], in the study of the nature of bacterial removal in filtration plants. In this discussion, it was suggested that "the normal performance of a water filtration plant may be represented by a curve having the equation: $y=x^c$, where y and x are respectively the raw water and final effluents counts, and c is a constant for the particular plant under discussion." In other words, the tentative hypothesis was brought forth that the final effluent count, on the average, is an exponential function of the raw water count. The evaluation of "c" replaces also the unsatisfactory percentage efficiency as a more adequate measure, by using the ratio of the logarithms of the counts instead of the ratio of the actual bacterial values.

It is apparent that a measure of performance to be effective for adaptation to quality interpretation should include more than an array of its daily values, since it is the *consistency* of bacterial removal which predetermines the position of a form of treatment in the scale of the safety of a supply. Heretofore, no single unit of measure of this degree of consistency of removal has been available, although the fitting of normal performance data to the logarithmic curve of filtration supplied at least a graphic method of testing consistency.[23] If bacterial data are arranged and plotted on the probability paper already referred to in the discussion, it becomes extremely easy to obtain the values of the semi-interquartile ranges of the figures in successive steps of purification. The ratio of such values of the ranges for any two steps appears to the writer to present some promise of a real measure of the "levelling" effect of purification processes, since it measures the change produced in the frequency distribution of bacteria in passing through the treatment. The demonstration of its value may be more apparent to the reader by reference to material given elsewhere.[24]

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INCOMES OF BITUMINOUS COAL PRODUCERS

By E. A. Goldenweiser, *Federal Reserve Board*

An interesting table of the incomes earned by 1,551 coal producers in 1918 is included in the report of the Bituminous Coal Commission. The figures are based on returns made to the Bureau of Internal Revenue by producers of coal in connection with their declaration of income and excess profits. While there are perhaps 7,000 producers of coal, the Bureau of Internal Revenue was able to find complete returns for only those firms included in the tabulation. There was no conscious selection by the bureau, and the incompleteness of the list is due to the fact that among producers of coal are many companies engaged primarily in other business, and not, therefore, identifiable as coal companies. It is also true that in selecting the coal companies the clerks in the Internal Revenue Office, being unfamiliar with the industry, were likely to overlook companies that made no mention of coal in the company name. There were also several companies whose income tax returns were still under consideration and whose schedules were for that reason not in the statistical office at the time the tabulation was made.

The companies included in the table produce 30.7 per cent of the total coal output of the United States. A very careful analysis of the concerns included, convinced Mr. F. G. Tryon of the Geological Survey that if all of the companies had been included the results would not have been greatly different from those shown in the table. The companies are fairly well distributed as to size and geographical location, and, although the tabulation is incomplete, it may be considered as sufficiently representative to be significant. The table as printed in the report of the Commission is reproduced here without change.

An additional table showing certain items per ton and the average tonnage per company in each income group, is presented.

It will be noted that the classification of the companies is by percentage of net income on invested capital before deduction of tax. This classification is weak to the extent that invested capital is a bugaboo in accounting and in the work of the Bureau of Internal Revenue. It is, of course, much more significant than capitalization, which has no necessary relation to anything except the ownership of the equities in the concern. One criticism of invested capital is that it includes many large holdings of coal lands, which, though not at present being worked, are held for their future value. Coal mines thus unexploited

TABLE I.

TABLE PREPARED FROM 1,551 RETURNS OF NET INCOME FILED BY BITUMINOUS COAL-MINING CONCERNS FOR 1918, DISTRIBUTED ACCORDING TO THE RATIO OF NET INCOME OR NET LOSS TO INVESTED CAPITAL, SHOWING THE NUMBER OF RETURNS, THE AGGREGATE AMOUNT OF CAPITAL STOCK, INVESTED CAPITAL, NET INCOME, INCOME TAX, WAR PROFITS AND EXCESS PROFITS TAX, TOTAL TAX, AND THE NET INCOME AFTER DEDUCTING TAX; ALSO FOR THOSE RETURNS REPORTING LOSS, NET AGGREGATE LOSS. (ALSO TOTAL TONNAGE FOR 1918, SUPPLIED BY THE GEOLOGICAL SURVEY.)

	Number	Capital stock	Invested capital	Net income	Tax			Net income after deducting tax	Average per cent of net income to invested capital before deducting tax	Average per cent of net income to invested capital after deducting tax	Tonnage
					Income tax	War profits and excess profits tax	Total tax				
A. Returns reporting income: Ratio of net income to invested capital (per cent)—											
Less than 5	168	$28,582,464	$41,932,284	$897,407	$81,675	$1,492	$83,167	$814,240	2.14	1.94	9,452,285
5 to 9.99	159	51,082,688	73,668,946	5,819,355	641,328	70,249	711,577	5,107,778	7.90	6.93	18,292,627
10 to 14.99	158	61,005,338	94,881,065	10,798,316	1,150,697	1,084,054	2,234,751	8,563,565	11.38	9.03	26,433,974
15 to 19.99	134	39,062,476	76,089,233	12,925,742	1,037,659	3,661,204	4,898,863	8,026,879	16.99	10.55	26,750,835
20 to 24.99	103	16,742,404	47,264,900	10,886,366	806,626	3,796,539	4,603,165	6,283,201	23.03	13.29	15,443,012
25 to 29.99	66	11,085,063	22,841,827	6,184,866	377,269	2,839,684	3,216,953	2,967,913	27.08	12.99	9,965,090
30 to 39.99	125	17,955,923	34,512,152	12,232,299	662,260	6,400,444	7,062,704	5,169,595	35.44	14.98	20,837,882
40 to 49.99	74	14,150,490	26,238,024	11,336,439	557,200	6,471,382	7,028,582	4,307,857	43.20	16.42	15,693,759
50 to 74.99	97	6,266,100	15,216,439	8,930,410	430,340	5,146,941	5,577,281	3,353,129	58.69	22.04	11,806,639
75 to 99.99	65	2,598,851	6,667,509	5,735,847	247,899	3,514,584	3,762,483	1,973,364	86.03	29.60	7,987,053
100 to 149.99	39	2,077,885	3,588,619	4,296,253	178,907	2,778,866	2,957,773	1,338,480	119.72	37.30	4,373,005
150 to 199.99	12	249,572	424,511	756,770	33,080	456,420	489,500	267,270	178.26	62.96	910,734
200 to 299.99	8	115,700	137,597	351,451	13,205	224,930	238,135	113,316	255.42	82.35	498,365
300 to 399.99	2	4,300	11,772	39,366	2,532	14,265	16,797	22,569	334.40	191.72	144,656
400 to 499.99	2	18,000	33,244	138,072	5,102	91,546	96,648	41,424	415.33	124.61	166,181
500 and over	2	5,300	11,824	125,248	7,389	59,669	67,058	58,190	1,059.27	492.13	137,254
Total reporting net income	1,214	251,002,554	443,520,546	91,454,207	6,233,168	36,812,269	43,045,437	48,408,770	20.62	10.91	168,893,351
B. Returns reporting loss: Ratio of loss to invested capital (per cent)—											
Less than 5	106	9,593,808	14,468,873	340,894*	.....	.....	.....	.....	2.36*	.....	3,901,970
5 to 9.99	58	3,935,362	5,129,012	359,162*	.....	.....	.....	.....	7.00*	.....	1,991,389
10 to 14.99	32	3,146,905	3,034,632	390,149*	.....	.....	.....	.....	12.86*	.....	1,488,947
15 to 19.99	29	1,471,750	1,602,321	278,449*	.....	.....	.....	.....	17.38*	.....	1,001,002
20 to 24.99	20	1,105,860	1,267,789	287,823*	.....	.....	.....	.....	22.70*	.....	606,234
25 and over	92	1,679,154	1,942,604	963,255*	.....	.....	.....	.....	49.59*	.....	2,019,994
Total reporting loss	337	20,932,839	27,445,231	2,619,732*	.....	.....	.....	2,619,732*	9.55*	.....	11,009,536
Total A and B	1,551	271,935,393	470,965,777	88,834,475	6,233,168	36,812,269	43,045,437	45,789,038	18.86	9.72	179,902,887

*Loss.

TABLE II.

TABLE FROM 1,551 RETURNS OF NET INCOME FILED BY BITUMINOUS COAL MINING CONCERNS FOR 1918, DISTRIBUTED ACCORDING TO THE RATIO OF NET INCOME OR NET LOSS TO INVESTED CAPITAL, SHOWING THE TONNAGE PRODUCED PER COMPANY, THE INVESTED CAPITAL PER TON, THE NET INCOME PER TON, TAXES PER TON, AND THE NET INCOME PER TON AFTER DEDUCTING TAXES.

Income group	Per ton				Number of companies	Tonnage produced per company
	Invested capital	Net income	Taxes	Net income after deducting taxes		
Average for all companies:	$2.62	.49	.24	.25	1,551	115,992
Companies reporting net losses of:						
25% and over	.96	.48*			92	21,956
20–25%	2.09	.47*			20	30,312
15–20%	1.60	.29*			29	34,517
10–15%	2.04	.26*			32	46,516
5–10%	2.57	.18*			58	34,334
Less than 5%	3.71	.09*			106	36,811
Companies reporting net incomes of:						
Less than 5%	4.44	.09	.09	.09	168	56,264
5–10%	4.02	.32	.04	.28	159	115,048
10–15%	3.58	.41	.08	.32	158	167,304
15–20%	2.84	.48	.18	.30	134	199,633
20–25%	3.06	.70	.30	.41	103	149,932
25–30%	2.29	.62	.32	.30	66	150,986
30–40%	1.66	.59	.34	.25	125	166,703
40–50%	1.67	.72	.45	.27	74	212,078
50–75%	1.28	.76	.47	.28	97	121,718
75–100%	.83	.72	.47	.25	65	122,879
100–150%	.82	.98	.68	.31	39	112,128
150–200%	.47	.83	.54	.29	12	75,895
200–300%	.28	.71	.48	.23	8	62,296
300–400%	.08	.27	.12	.16	2	72,328
400–500%	.20	.83	.58	.25	2	83,091
500% and over	.09	.91	.48	.42	2	68,627

* Loss.

naturally tend to decrease the percentage of net income. There may, therefore, be some question as to whether this inclusion is fair or not. However, in view of the fact that a coal mine is depleted with comparative rapidity, the holding of unexploited mine lands, with the resulting interest charge, may be considered as a part of the business. As an offset may be mentioned the fact that many companies have leaseholds on coal lands for which they pay a contract price far below the present market price; this element would tend to increase the proportion of net income to invested capital. There is room for debate on the validity of the investment figures, but it may perhaps be said with fairness that, since the basis throughout the tabulation is uniform, the figures are significant as between group and group, even though they may not offer a sufficient basis for final judgment as to the amounts earned by the coal producers.

The Report of the Bituminous Coal Commission points out that of the 1,551 companies included, 337, or 22 per cent, reported net losses in 1918, and 168 companies, or 11 per cent reported net incomes of less than 5 per cent on invested capital. One-third of the companies involved, therefore, were not making what may be considered a fair return on their investment. The significant fact, however, is that these companies represent only about one-seventh of the total invested capital, and about one-ninth of the total tonnage. Since the capacity of our coal mines is approximately 700 million tons per year, and the national requirements are approximately only 500 million tons a year, it is clear that the nation's needs can be supplied even if these unprofitable companies are diverted into other lines of business. In fact, there is no hope for a thorough stabilization in the coal mining industry unless the high-cost mines are shut down, at least temporarily.

The coal mining business requires, in many cases, comparatively little capital, and even before the war many concerns were engaged in coal mining on a speculative basis; that is, small concerns acquired entries which they held against the day when a heavy seasonal demand would make it profitable to work the mines. Such producers might enter the field in the fall months, operate for a few weeks and realize enough during that period to pay for their comparatively small investment. In trade parlance, such producers are called "snow birds" because they ordinarily operate when there is snow on the ground and when the demand for coal is at its peak. Owing to the exceptional demand for coal, and because of the fact that the government fixed the price of coal on a basis sufficiently attractive to induce all companies to increase their output to meet the exceptional national requirements, the number of high-cost mines increased materially during the war and other mines were induced to expand their production beyond the limits which national economy in times of peace would justify. There is little question that those producers whose operations were profitable only because of exceptional demands caused by the war, will be forced out on the return of business to normal conditions. This is only fair as the nation cannot be expected to support uneconomic mines simply because they happen to be in the field. If, in individual instances, it could be demonstrated that the mines were operated on a purely patriotic basis in order to help the nation in its hour of need, the American people could much better afford to refund to such proprietors the whole of their investment rather than attempt to maintain a price that would make it possible for them to continue in business.

In view of the large number of companies involved and the keen

competition which prevails in the industry there is little danger of price agreements that would enable the unprofitable mines to operate. It is to be expected that the nation's coal requirements will be supplied by companies having sufficient natural or geographic advantages to be able to produce coal at a figure representing a peace-time "bulk line." Only by establishing this basis of production, and coupling with it the plan of the Coal Commission to provide an even distribution of the demand throughout the year by inducing the large consumers to purchase their supplies in the summer months, can the industry be placed on a stable basis which will insure during twelve months of the year profitable employment for the capital and the labor involved. It is well known that at the present time only about two-thirds of the working days are days of operation in the coal mines. From the national point of view there is no justification for supporting what may be termed excess capital and labor in the industry. Moreover, the resulting intermittency of employment has been the main cause of labor unrest, on the one hand, and of the serious car shortage during the rush season, on the other.

The table shows further that about 36 per cent of the operators having about 62 per cent of the total invested capital and producing about 48 per cent of the total tonnage were earning between 5 and 25 per cent on their investment. This group may therefore be considered as carrying the bulk of the coal production. Other companies, still more fortunately situated, made much larger returns, and it is the returns of these companies that have given rise to a great deal of public discussion. It is significant that the companies making over 25 per cent return represent only about one-fourth of the total investment and two-fifths of the tonnage, while the companies making returns of over 100 per cent represent only about 4 millions of investment and about 6 millions of production. The companies reporting very high rates of return on their investment are small concerns with investments of only a few thousand dollars whose net income represents to a large extent the earnings of the owners for their own labor, management and risk. They are speculative investments and, although they may make 100 per cent on their money one year, market conditions may be such in subsequent years as to make it unprofitable for them to operate their mines at all. In fact, it is to be expected that under present conditions these small concerns will not be able to operate and that their short-lived war profits will represent perhaps all of the return on their investment.

The table of averages shows that the 1,551 companies included produced about 116 thousand tons per company and that the pro-

duction of the companies reporting losses was, in the case of no group, greater than 47 thousand tons a year. The companies having net incomes of less than 5 per cent averaged only 56 thousand tons a year, while the companies in the other income groups had very much larger average productions. The companies earning between 15 and 20 per cent produced about 167 thousand tons per company and the 74 companies earning between 40 and 50 per cent produced an average of 212 thousand tons a year. It is of interest that the companies in the income groups above 200 per cent averaged less than 76 thousand tons a year.

For the companies earning net incomes, invested capital per ton decreases with almost unbroken regularity as the income earned by the group increases. In other words, the main reason for good profits in the industry is the possession of a mine which assures a large coal output per dollar invested. The companies earning less than 5 per cent have an average investment of $4.44 per ton, while those earning 500 per cent and over have an average investment of 9 cents per ton of output.

On the other hand, it is significant that net income per ton does not increase with any degree of regularity with the increase in the returns on investment. Although the companies earning less than 5 per cent earned only about 9 cents per ton, the companies earning between 20 and 25 per cent earned 70 cents per ton, as compared with 62 cents and 59 cents per ton respectively for the companies in the two succeeding income groups. The largest earnings per ton—98 cents—are shown for the companies with a return of between 100 and 150 per cent on their investment, while the companies earning between 300 and 400 per cent earned only 27 cents per ton. In other words, the determining factor is a large output per dollar invested rather than a large profit on each ton produced.

The average amount of capital invested per ton of product for all of the 1,551 companies included was only $2.62, which is perhaps the principal reason why expansion of the industry beyond the economic limit has prevailed. An investment of only $2.62 per ton of coal, which is considerably less than the selling price per ton, is indicative of an industry in which labor cost and risk are the fundamental elements determining cost in the long run. On the investment of $2.62 per ton the companies, including the losing concerns, earned on the average a net income of 49 cents per ton, of which the government took 24 cents in income and excess profits taxes, leaving 25 cents available for distribution among the proprietors. A net income, above taxes, of 25 cents per ton would seem to indicate that the industry on the

whole was on a substantial basis of profit in 1918, which was a good year, although after the signing of the armistice production fell off materially.

The Bureau of Internal Revenue, which very properly guards with extreme care the private information of the taxpayers, seldom gives to the public a statement of facts sufficiently illuminating to furnish an insight into the financial conditions of an industry. There are those who maintain that income and excess profits tax returns should be a public record available for the inspection of any taxpayer. While such a degree of publicity is of questionable desirability, since it would be likely to operate against the accuracy and the truthfulness of the returns, it is certain that tabulations like those presented in the report of the Bituminous Coal Commission and reproduced here are of great public interest. It is equally certain that the economists and statisticians of this country would do well to encourage the Bureau of Internal Revenue to compile summarized statements of the earnings of companies in different industries. Such compilations reveal no individual's private business, and at the same time furnish a mine of valuable information regarding economic conditions in the different industries.

REVIEWS

Economic Phenomena Before and After the War; A Statistical Theory of Modern Wars, by Slavko Secerov. London, Geo. Routledge & Son, 1919. Pp. viii, 232.

This thesis, presented for the M.Sc. degree in Economics at the University of London, is an interesting but somewhat disappointing work. Although the theoretical reasoning is much better than the statistical support presented, yet some features of the theory do not seem cogent even on purely *a priori* grounds.

The main contention of the study is that war is a function of increasing disturbance of the economic equilibrium in advanced industrial communities. The state of economic equilibrium is a result of a balance between the factors of production and consumption. On the side of production chief importance attaches to the relative proportions of primary and secondary goods, when by primary goods is meant food and raw materials, and by secondary goods, manufactured articles. Primary goods are produced under the law of decreasing returns, secondary goods under that of increasing returns. The capitalistic community is under a constant propulsion to decrease its production of the former and increase the production of the latter, seeking, at the same time, to maintain a balance between the two by trade with less advanced communities, which are themselves being pushed toward industrialization by the accumulation of capital. On the side of consumption chief importance attaches to the growth of population and changes in the standard of living. In general, then, the thesis is that in advanced industrial communities there is a marked tendency for the production of primary goods to fall behind the growth of population and the rise in standards of consumption. This gradual disturbance of the economic equilibrium is corrected by war which checks the production of secondary goods, stimulates the production of primary goods, reduces population and depresses the standard of living.

Thus far the thesis is one that has in substance been expressed before (E. Van Dyke Robinson, *War and Economics in History and in Theory*, Pol. Sc. V. 15, pp. 581–622; W. S. Thompson, *Population, A Study in Malthusianism;* and E. Dana Durand, *Some Problems of Population Growth*, Quar. Pubs. A. S. A. V. 15, pp. 129–148) and even more effectively, for the style of this book is frequently marred by foreign accent. But the author further refines and elaborates his theory. In the first place the marriage rate, the death rate, and hence the rate of population increase are dependent on the ease of earning a wage sufficient to maintain the standard of living. This can be shown by a comparison of price index-numbers and percentages of increase in population. This has considerable validity in theory but the figures used (Table I, p. 50) indicate that the rate of population growth varied directly with the price level, especially if a lag of ten years be allowed. "As the increase rates fell from 18.1 per cent in 1811–21 to 11.9 in 1851–61, the average price index numbers fell from 156 to 89, etc." (p. 51). This means that a rise in prices stimulates population increase and vice versa, a conclusion contrary to his own theory and to common sense. Fortunately for the author's peace of mind this table is brought down to the close of the century only. Could he today contend that the rapid rise in prices in England and Wales since 1900 has been paralleled by growth of population? The fact is that for a generation the birth rates in Western Europe have been declining so that the secular changes of price levels and of birth rates were directly correlated for some years before 1896. But these secular movements of prices and birth rates have been inversely correlated since. Moreover the author does not either theoretically or inductively

show that short-term fluctuations of price levels and population movements are related.

But there is an additional aspect to the theory of population movements, namely, that (1) a special pressure of population on living conditions is shown immediately before war, while (2) there is a release of reproductive forces immediately following war. This last proposition has long been accepted and explained as a consequence of the check which war inevitably gives to marriage and marital relations. The author however contends that this post-war "ascending phase" of population growth is due to (1) a lowered standard of living and (2) greater ease of getting a living, largely owing to the loss of life during war. This explanation is left in the realm of *a priori* reasoning. Moreover the assertion (p. 68) that in the post-war period "the winning party is progressive, the losing stationary or retrogressive" is not demonstrated; it is in fact directly contrary to all data presented (pp. 56–61).

As to "the pre-war declining phase" of population growth, the author nowhere makes a convincing case. His best case is that of Prussia and France and the War of 1870–71. Take France, for example. By taking the years 1867–69 as the pre-war period he shows (p. 57) a decline as follows: 1867, 3.7 per 1,000 population; 1868, 1.6; 1869, 2.2. But one could do equally well by selecting other dates. Thus: 1863, 4.4; 1864, 3.9; 1865, 2.2. Moreover by starting at the low point of 1865 one could almost show a pre-war *ascending* phase, the figure for 1866 being 3.2. The drop in 1868 and 1869 is not less striking than the fall from 3.2 in 1856 to 1.1 in 1859 or the rise again to 3.7 in 1861. In Prussia the presence of cholera during the pre-war years admittedly caused such violent fluctuations as to obscure the operation of economic factors.

The author's study of data preceding the Great War is even less convincing. There has been a general tendency toward a decrease in the growth of population in all western Europe. If one is to find in that an indication of approaching war he will see only what one can see even more plainly where population is increasing. Moreover the fluctuations from year to year cannot be made the basis for statistical proof unless they are separated from the general trend and shown to be of significant proportions. Thus a decline in the French rate of growth from 1.5 in 1912 to 1.3 in 1913 can hardly "be taken as significant for forces affecting equilibrium" (p. 64) in view of the statement on the same page to the effect that the rates varied as follows: 1908, 1.2; 1909, 0.4; 1910, 1.8; 1911, 1.1. The drop from 1908 to 1909, or 1910 to 1911, or the rise from 1909 to 1910 was in each case several times greater than the fall 1912–1913. This instance is typical of much of the author's work. There is an uncritical and not altogether candid use of statistics; there is also no device for testing whether a difference is significant or not.

But equally important with growth of population, in the opinion of the author, is growth of consumption. His theoretical discussion is interesting and illuminating. With a rise in the standard of living, consumption of both primary and secondary goods is extended. Thus industrial communities produce proportionately less primary goods while steadily demanding more; at the same time they advance rapidly their production of secondary goods. The increased pressure upon the supply of primary goods has the effect of checking population growth so that, "if there is a steady and continuous decline in the rate of the natural growth of population, and a steady rise of consumption war is probably approaching" ("General Summary," p. 188). This quotation embodies the most unique proposition in the study,—a proposition that is far from demonstrated. He can show an increased per capita consumption of various fundamental foods during the 19th century, but he cannot show

convincingly either "a pre-war declining phase of the natural growth of population" or "a pre-war ascending period of consumption" (p. 105). His study of consumption is subject to criticisms similar to those already noted regarding his treatment of the subject of population. Take, for example, the Franco-Prussian War, pp. 110–117. In Table 22 he presents the annual per capita consumption of wheat and rye in Prussia. But before noting figures it should be mentioned that the author adds still another special quirk to this theory by contending that the imminent approach of war is indicated by a "special pressure area" of two or three years. In other words war is made probable by a persistent rise in the standard of consumption (plus lessened growth of population) and is virtually ushered in by a sudden decline of consumption. Data for Prussia are scarce and faulty "but the available statistics confirm the theory." Table 22 gives the per capita consumption of wheat and rye, during the years 1856–69, as follows: 1856–58, 173.2 kgs; 1859–61, 169.8; 1862, 161.1; 1863, 163.4; 1864, 166.9; 1865, 162.2; 1866, 162.2; 1867, 155.9; 1868, 149.8; 1869, 156.0. Presumably the years 1862–67 (or 1866) are the years of ascending consumption, and the years 1868 and 1869 those of "pressure on consumption." Several things may be said about these figures: (1) if one take the average for the eight years 1854–61 (figures for 1853–55 average 159.3) he gets 167.4, while the average for the eight pre-war years is only 159.7; thus the ascending phase becomes descending; (2) why do they not show the wars against Denmark and against Austria in 1864?; (3) elsewhere, when using agricultural data that do not fit, the author explains them away as due to the fluctuations of nature, as on the next page where he finds he cannot rely on wheat and potatoes for France for the figures are "irregular, probably due to bad harvests." There are four such excuses in eight pages (112–119). Hence for Prussia he uses wheat and rye because they fit; for France he cannot use wheat and potatoes and falls back on sugar and five drinkables, wine, spirits, beer, cocoa and tea. Apparently the French had little use for solid foods before the War of 1870; perhaps the true cause of the war was that excessive drinking on otherwise empty stomachs aroused an excess of martial spirit. The figures for Paris are no more convincing. Here data for meat consumption are given but they decline from 1864 to 1867 inclusive when they should rise, and then, during the "special pressure" period heralding the coming of war, they go up. What can a statistician do with such perverse figures, anyway, but to set them down and ignore them! His case is not strengthened, even by the further data giving the per capita consumption of *vanilla* and *pepper* for all France.

This sort of criticism could be extended indefinitely, especially if one were to take up the data given for years preceding 1914. There is reliance on chance variations, emphasis on insignificant differences, and crude handling of averages (pp. 144 and 145). Excuse is offered for data that do not fit but use is made of exactly similar data when they happen to fit the theory.

There is still a final proposition, namely, that war reëstablishes equilibrium by increasing the production of primary goods. Here again the author seems unable to make a clear case statistically. His theory that such production increases during war and that, following war, it continues to increase in the losing territory, seems sound enough; as does also the theory that such production will decrease in the winning territory because the object of war is to acquire control of supplementary areas which will provide foods and raw materials. But one cannot readily apply the same reasoning to Russia in the Russo-Japanese war and to England in the British-Boer war, owing to enormous differences in stages of economic development. Moreover the fluctuations in crop acreages from year to year are such that, in the absence

of some method of showing general trend and the significance of variations therefrom, the statistical table becomes meaningless.

In spite of failure to establish clearly the special features of his theory, the author has given us another demonstration of the fact that the progressive industrialization of the Western World must encounter increasing difficulties as other communities move in the same direction. As supplementary areas grow small and gradually become barely self-sustaining, or even partially dependent as regards foods and raw materials, the capitalistic phase of world development must gradually give way to one in which standards of taste are less pecuniary and industrial organization less exploitative.

F. H. Hankins.

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The Italian Emigration of Our Times. Robert F. Foerster. (Harvard Economic Studies, Vol. XX.) Boston, Harvard University Press, 1919. Pp. xv, 556.

Dr. Foerster has produced a book for which all students of migrations will be grateful. It unmistakably shows a first-hand knowledge of the conditions of the Italian emigrant both at home and abroad, as well as a complete mastery of the literature. Moreover, unlike the work of most American scholars, it is written in a graceful style, rising at times to real beauty and distinction.

What distinguishes Dr. Foerster's work from that of most writers upon the subject is that, like Miss Balch, he rightly makes emigration from the homeland, rather than immigration into any one country, the center of the problem. As the result of an admirable statistical study, he shows that in the forty years preceding 1914, between sixteen and seventeen millions of emigrants left Italy. This figure, however, represents a certain amount of duplication since it includes the reëmigrants and the seasonal laborers who, before the war, went forth annually to work in the European countries and even as far away as Brazil, only to return in the winter. Dr. Foerster estimates that of the total emigration, approximately two-thirds was temporary and either had returned or would return to Italy. Something over four millions, however, had been finally lost to the country.

The early emigrants came chiefly from the northern provinces, but since 1900, the south has furnished the chief source. Four-fifths of them are males and the great majority unskilled laborers coming from the rural districts.

The forces causing this unparalleled migration are impelling rather than alluring. The emigrants are driven out by the economic pressure of an overcrowded population working upon infertile soil with the most primitive of tools and rudimentary of agricultural practices. Added to this is the system of large landed estates whereby high rents are exacted by absentee landlords and in the south the widespread prevalence of malaria. The inevitable result is a condition of misery which, in Sicily and the south especially, was scarcely equalled in any European country prior to the war.

Such, then, are the causes which have brought about this exodus of millions. Where have they gone? Everywhere that there has been economic opportunity. Both in the causes of emigration and in the direction which it has taken, economic factors, therefore, have almost completely predominated. Dr. Foerster describes, with a wealth of detail, the wide distribution of the emigrants. Large numbers have entered every European country, save Great Britain and Russia. Dr. Foerster points out the little known fact that of the transoceanic emigrants, the majority have gone to Argentina and Brazil. His chapters on the migrations to these countries are indeed a unique contribution. He computes that the native-born Italians form as

much as one-seventh of the total population of Argentina while the Italian stock as a whole comprises approximately one-third. Most of the migrations to South America occurred prior to 1900, and consequently were largely composed of emigrants from the north. Since then, the main channel of emigration has of course been to the United States and has been composed chiefly of south Italians. Great as has been the Italian immigration into this country in the last twenty years, it has not as yet equalled the total number that have entered Argentina and Brazil.

The conditions of life of the Italians abroad are, with few exceptions, but slightly less severe than in Italy itself. They are almost uniformly unskilled laborers, whether they are at work in the mines of Germany and France, on the construction jobs or in the harvest fields of central Europe, the coffee plantations of Brazil, or in the mines, manufacturing industries and construction camps of the United States. Relatively few become skilled craftsmen, although many enter the small merchant class. In the Argentine the rigorous labors of the Italian immigrants have been largely absorbed by the native landed aristocracy in the form of enhanced land values and rentals while the Italians themselves have not prospered in proportion to their efforts.

Low as their wages have been, Italians abroad have sought desperately to save in order that they might return to Italy with "their pile." Their low wages, their desire to save, and their previous low standards all cause their mode of life in foreign lands to be unsanitary and unsuitable. Moreover, the same forces have led them in industry to overstrain both themselves and their families while the individualism born of the desire to return to Italy deters them from combining with their fellow-laborers to better their condition. They have in short furnished excellent material for exploitation, whether by landlord, employer, or unscrupulous fellow-countryman.

The effects upon Italy itself have been noteworthy. The money wages of the agricultural laborers who have remained behind have risen, although it is doubtful whether real wages, save in one or two provinces, have increased appreciably. Nor have the returned emigrants improved the agricultural practices. Despite the millions that left the country from 1880 to 1910, the population of Italy increased more rapidly than ever before. This increase, however, was largely secured by the cities, for along with emigration from the country, has gone the characteristic migration within the country from the rural districts to the cities. Dr. Foerster is inclined to believe that emigration has not resulted in a smaller population for Italy as a whole, due to the fact that the excess of births over deaths has increased. This has been caused by the great reduction in the death rate without an appreciable reduction in the birth rate. Of late, however, Dr. Foerster, points out that the birth rate has fallen, notably in Piedmont as a result of the return of the emigrants from France.

Dr. Foerster urges as a program of economic betterment not the encouragement of further emigration, but instead internal reforms. His program includes: (1) the rehabilitation by the government of the agricultural lands of the south by means of reforestation, drainage, irrigation and the construction of roads, (2) the breaking up of the estates into more moderate holdings with the substitution of the cash rental for the metayer system, (3) the introduction of modern farming machinery and practices, (4) the establishment of a universal free system of education. For those who do leave the country, Dr. Foerster would continue the oversight already exercised by the Italian government and would add the establishment of standards which must be met to permit of emigration, the creation of an international labor exchange to adjust seasonal demands for and supplies of labor, the protection of the emigrant while en route and the formulation of a uniform international code defining the rights of aliens.

It is extremely doubtful, however, in the opinion of the reviewer, whether these measures would achieve any permanent gains unless they were accompanied by a thoroughgoing decrease in the birth rate. Dr. Foerster avoids this question but it is one that should be considered in any adequate discussion of Italy's population problem.

Such a reduction in the birth rate would undoubtedly meet with opposition both from the Catholic church and from the imperialists and militarists. The church would object because it has always stood for a maximum increase of its membership. The militarists and imperialists want a surplus population to man the new empires, that they are hoping to stake out in Dalmatia, North Africa and Asia Minor and to form the armies necessary to maintain and enlarge these dominions.

PAUL H. DOUGLAS.

Statistics in Business.—Their Analysis, Charting and Use. By Horace Secrist, Ph.D. New York, The McGraw-Hill Book Co., Inc., 1920. 137 pp.

As stated by the author in his brief preface, this book is intended primarily for the business executive, and with this purpose in mind the treatment is concrete and concise. In the reader's opinion it should prove valuable to the busy executive in suggesting phases of business for scientific study. The material it contains is not mathematical, and can be grasped by persons possessed of little or no knowledge of the scientific aspects of statistics.

The first three chapters, covering forty pages, define and describe the facts of business—any business. We are told how to recognize business facts and where to find available sources. The fourth chapter, under the title of "Classifying and Tabulating the Facts," gives a short and lucid description of the correct and incorrect methods of tabulating statistical data. The author has illustrated the text with several tables and has indicated their good and bad features. Certain fundamental principles are given for the preparation of schedules for the collection of data: (1) Coöperation must be solicited. (2) Inquiries should be brief and to the point. (3) The forms should be simple and not involve an undue amount of labor. (4) The questions should be answerable so far as possible by yes or no or by a simple answer.

After having first shown us how to define and to recognize and then to collect and tabulate our facts, the author in the fifth chapter shows us how to present them in a striking manner by the use of graphs. Rules for charting as well as a description of the various methods and materials used, are treated with sufficient detail as to be a comprehensive survey of the subject. The criticism may be made, however, that often the illustration and the text are not on the same page, making it necessary that the reader turn over several pages when referring to the diagram. This arrangement is not conducive to a close study of the diagrams, and the tendency would be to read the text and casually refer to the illustrations, not giving them the careful attention they deserve.

The closing chapters of this small volume treat the methods of summarizing the results obtained from the tabulating and charting of data. The author devotes some consideration to the discussion of the use and advantages of the average as well as to business principles and standards. In his opinion there are two stages in the application of scientific methods to business or other phenomena: (1) scientific observation and (2) logical inference. It is only by passing through both that a science of business can be developed.

R. L. WHITE.

Vital Statistics: An Introduction to the Science of Demography. By George Chandler Whipple. New York, John Wiley and Sons, 1919. pp. 517.

The outstanding characteristic of Professor Whipple's book is the effective, simple, and forceful way in which the content, and some of the methods, of vital statistics are explained for the benefit of the public health student and the busy health official. Students of the political sciences have for years had the more comprehensive treatise of the late Professor Richmond Mayo-Smith, "Statistics and Sociology," the works of von Mayr, Westergaard, Grotjahn and Kaup, Lexis and many others to guide them, but, with the exception of Dr. Newsholme's "Vital Statistics," an English publication long unobtainable through American book-sellers, the public health student has had no text for study. The lack of such a work may have been responsible for the backward condition until very recently prevailing in the registration and tabular display of vital facts in the United States.

Professor Whipple has wisely discussed his subject in the most elementary manner, and by so doing has made vital statistics attractive to the registrationists and to others in public office who control the collection of the basic facts and the ensuing crude tabulations. These form the building materials out of which the professional analyst, the statistician, erects his structures of induction, and of hypothesis and deduction for the guidance of the statesman. It is not difficult to write a textbook on vital statistics in the necessarily involved philosophical language of interpretive statistics. Professor Whipple could have done that, no doubt; but it would not have filled the need of the hour in vital statistics; he would not have brought home to the ever-increasing number of local registrars the elementary, indispensable criteria of crude descriptive vital statistics. Professor Whipple chose the more difficult task of discussing "first things first."

The first chapter is devoted to a brief history of statistics and of vital statistics, to the uses of crude descriptive data in health administration, and to an elementary discussion of the place of logic in statistics. The two following chapters give practical hints on office technique,—tallying, hand and machine tabulation, table structure, computation of ratios, the use of logarithms and the slide-rule, the seriation of data, and graphic methods.

Enumeration and registration requirements for population statistics, and for births, marriages, divorces and sickness are taken up in Chapter IV. The chief descriptive details of population structure are discussed, and this is followed by two chapters on crude and specific death rates, birth rates, marriage and divorce rates. The nomenclature and classification of diseases causing death are briefly outlined in Chapter VIII. Further comment is given in Chapters X and XI on the crude statistics of mortality from principal diseases and at the several age-divisions of life. A general description of life tables is to be found in Chapter XIV. For methods of computing these tables the student is referred, however, to other works, perhaps inaccessible to the public health official. This is to be regretted because there are elementary methods of compiling abridged life tables,—the Farr method, for instance, which could have been described. The explanation of osculatory interpolation as given by Mr. Burn in his "Vital Statistics Explained" is well within the comprehension of the local registrar who may wish to prepare a life table to show the results of health work.

It is doubtful whether the chapters on "Probability" and "Correlation" should have been included in this elementary work, because it is extremely difficult to teach these subjects to beginners in statistics with any certainty that the methods will not be misunderstood and, consequently, misapplied. This is true especially of measurements of contingency and correlation. As one experienced mathematical analyst has

remarked: "Mathematical methods when used by the non-mathematical statistician are as dangerous as a razor in the hands of an infant." The unfinished state of the theory of correlation, the fact that the teaching of the so-called theory of probabilities has not advanced in most of our universities beyond the elements as given in the average high-school or college algebra, the slight attention paid to mathematical-statistical logic in the United States, are sufficient reasons why the newly-introduced student should not be given an opportunity to confound himself with rule-of-thumb "statistical methods." On page 411, Professor Whipple says: "The student will find the use of the coefficient of correlation an admirable weapon for exploding false theories," and as an example, states that a coefficient of correlation of 0.54 between a series of grippe outbreaks in one year and of measles epidemics the next year, is "low correlation." He says: "It follows, therefore, that the statement that grippe is followed by measles a year later has little to substantiate it, if all the facts are considered." A coefficient of 0.54 is by no means "low."

Furthermore, the "correlation" was made from records of only 123 and 184 deaths in the two series, respectively, arranged in twelve pairs and for the state of Connecticut. Would it not have been better to show the need for more data by attaching the "probable error" of this particular coefficient 0.54? Then, again, would it not have been wise to ask for a tabulation of both grippe and measles facts by months instead of by calendar years, over a wider area so that the true periodicity of these diseases could have been shown? Epidemics do not respect artificial calendar year limits. It is not clear why the simpler method of "grade" or "rank" correlation (Spearman's method) was overlooked. Unless the student or public health official or statistician has been disciplined by a sound training and much experience in the basic mathematical studies and in higher statistical analytics and logic, he had better not undertake to support or explode theories of disease relationship and causality. It is much the wiser course to draw extremely reserved, common-sense conclusions from inspection of the crude data, leaving the testing, graduation and logical analysis to the professional statistician.

E. W. Kopf.

Decennial Census of the Commonwealth of Massachusetts, 1915. Taken under the direction of Charles F. Gettemy, Director of the Massachusetts Bureau of Statistics. Boston, Wright and Potter, 1918. Pp. ix+749, with map.

Massachusetts, in successfully taking a census of the population and principal material resources of the Commonwealth in a manner which merits the confidence of the student in the political and social sciences has again succeeded in doing something that no other American state has ever done. It would be idle to designate the states which in 1915 and in prior years failed more or less conspicuously in this important function of government. We can only hope that a sufficient number of the members of this Association in the several states, other than Massachusetts, will take the trouble to inquire, first, why there is no provision for taking an inventory of the human resources of their particular states at times midway between the federal enumerations, and, second, in case there is constitutional or sporadic legislative provision for a state census, why the methods of enumeration and general organization are so grossly defective, and why the published results are inadequate to meet the most elementary needs of state government. A state government cannot afford to fail to provide students of its problems with the most rudimentary facts as to the size of the population and its composition as to citizenship, nativity, color or race, sex, age, civil condition and occupation.

For a text on principles and methods of State Census-taking, inquirers should be referred to Mr. Gettemy's able "general introduction" to the 1915 census volume of his state. After an explanatory note on censuses of the Commonwealth from the earliest times, Mr. Gettemy discusses: purposes and scope of the census; provisions of the 1915 Census Act; organization and personnel of the census; publicity, preparation of schedules and forms, division of the state into enumeration districts, and selection of the field force. The actual enumeration processes and the methods of supervising enumerators' work, preventing fraudulent practices and duplication of enumeration, checking enumerators' errors, etc., are described. In this work of mapping enumeration districts, choosing, instructing and supervising the enumerators, most of the other state censuses fail utterly. The direction of the task of taking a census requires the services of a trained population statistician. Because of the very backward condition of state statistics, such service is rarely, if ever, obtainable from within the state government.

An interesting discussion of the system of card punching, verification and machine tabulation is given on pages 24 to 26.

In addition to a census of "the population and the number of legal voters, in accordance with the requirements of the Constitution, and the collection of such additional information relative to the composition of the population as might be deemed expedient by the Director of the Bureau," a census of fisheries and of commerce, a special investigation on the subject of aged dependents, a list of veterans of the Civil War and a list of blind persons were prepared. The special subjects represented in the many good tables shown in the volume cannot be listed here in full.

The first thirteen tables give information on the total population of the several civil divisions of Massachusetts according to sex, families, dwellings, density of population and housing within various municipal, judicial and congressional districts. The second section, seven parts of Table 14, shows the nativity, color, parentage, literacy, voting age, and general occupation classes of the population. Further elaboration of these elements is given in Tables 15 to 26. Detailed occupation statistics are presented in Tables 27 to 29. The Bureau of the Census classification of occupations, used in compiling the statistics shown in Volume IV, Thirteenth Decennial Census of the United States, was followed in the tabulation of the Massachusetts results. An important difference in the age limits of the federal and state statistics is to be noted. The federal figures for 1910 show occupations of gainfully employed persons ten years of age and over, whereas the Massachusetts 1915 data relate to persons fourteen years of age and over.

Appendix A gives the Act enabling the 1915 Census. The cards upon which the enumerators recorded the population data are shown in facsimile in Appendix E, while Appendix F consists of an historical survey of census taking in Massachusetts. The various methods adopted since 1780 for determining and apportioning the membership of the Commonwealth House of Representatives, the Senate and the Governor's Council are described. A bibliography of Massachusetts censuses concludes the work.

E. W. Kopf.

NOTES

DECREASE IN STATURE; NOTE ON THE MEDICO-ACTUARIAL MORTALITY INVESTIGATION

Some time ago the writer found it necessary to rearrange certain of the data for stature presented in the volumes embodying the results of the Medico-Actuarial Investigations. One of the points considered was that of the post-maximum change in stature.

Powys and Pearson* have treated this subject with great thoroughness on the basis of measurements of criminals from New South Wales. Goring† has analyzed his own data, painstakingly gathered in the British prisons. The Australian data include both men and women; the British returns are for men only.

For comparison I have abstracted the data for men over 24 years of age and for women over 21 years of age from 221,819 insured men and 136,504 insured women recorded by years of age and inches of stature.‡

These lower limits were selected because the data of Powys and Pearson and of Goring indicate that man attains his maximum stature in the age class 25–29 years. In New South Wales woman attains her maximum stature at about 25 years.

At ages earlier than this, stature is increasing with increasing age. At ages later than this, stature is decreasing with increasing age. The rates of pre-maximum increase due to growth and the rates of post-maximum decrease due to shrinkage are of course very different. Pearson and Lee§ attempted to fit algebraical expressions giving the smoothed values of stature for the whole age-range, but found the result unsatisfactory. The results of Powys, Pearson and Goring are consistent in indicating that from the age of maximum stature to old age the decrease in stature with age is as well described by a straight line as by that portion of any curve of a higher order fitted to the data as a whole.

The equations given by Pearson and Goring are:

For fraudulent British convicts, $s = 68.06 - .0341\ a$
For other British convicts, $s = 65.76 - .0133\ a$
For Australian male convicts, $s = 68.34 - .0337\ a$
For Australian female convicts, $s = 63.61 - .0361\ a$

In man the stature decreases from 0.013 to 0.034 inch per year, in woman 0.036 inch per year; both men and women will decrease about one-third of an inch for each 10 years after the age of maximum stature.

The equations deduced from the medico-actuarial data‖ are as follows:

For men, $s = 68.63 - .0030\ a$
For women, $s = 64.94 - .0197\ a$

These equations are represented by the lines in the diagram. The empirical means

* Powys and Pearson, Biometrika, 1901, vol. 1, pp. 38–49.

† Goring, The English Convict, pp. 191–193, 1913.

‡ Medico-Actuarial Mortality Investigations. Compiled and published by the Association of Life Insurance Medical Directors and the Actuarial Society of America, vol. 1, New York, 1912.

The crudeness of the measurements is frankly admitted by the Committee. Notwithstanding this fact it seems probable that with such large numbers the inaccuracies of the individual measurements will average out, and that the general means will be fairly trustworthy.

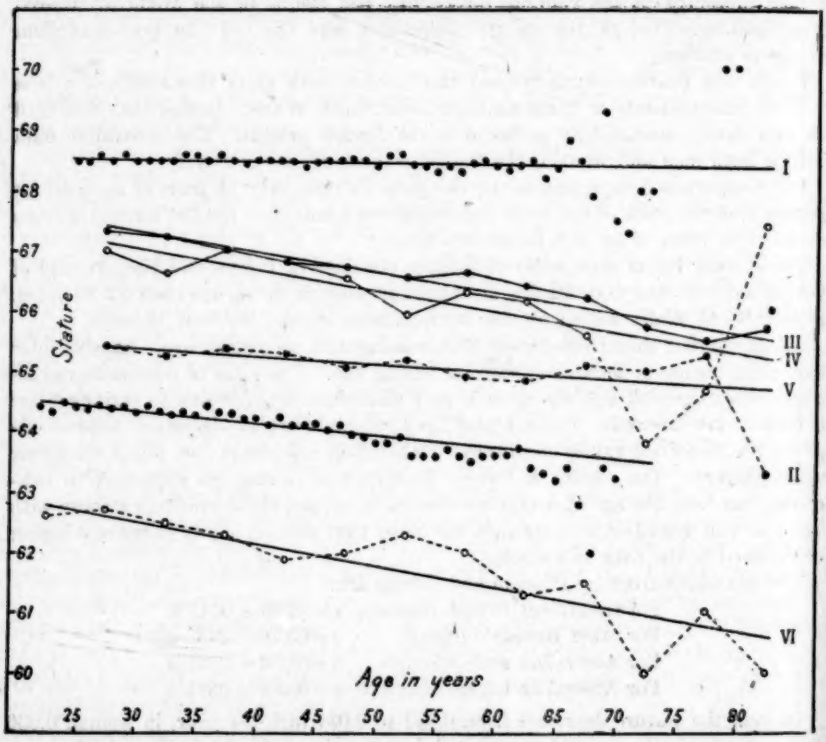
§ In memoir by Powys, Biometrika, 1901, *1*, pp. 48–49.

‖ For men, $N = 182{,}290$, for women, $N = 125{,}016$.

are given for quinquennial age groups for the Australian and British series, but for each year in the medico-actuarial series.

The lines and the empirical means for the American series show a clearly marked post-maximum decrease in the stature of the women. This is somewhat smaller than, but otherwise comparable with that found in the British and Australian series.* In the men, however, the decrease in stature is very slight indeed.

The results for these very diverse series are in fair agreement with the exception of those relating to American men. The crudeness of the measurements has already been



I, American men; II, American women; III, New South Wales male criminals; IV, British fraudulent criminals; V, British convicts other than fraudulent; VI, New South Wales female criminals.

noted. Again, the data are for insured lives and are therefore a selected class. *A priori* there is no reason to assume that men of 60 years who apply for insurance are of the same social class as men of 20 to 30 years. Among the latter there may be a much larger proportion of recent immigrants or of the first generation from immigrant parents, distinctly differentiated in stature from the older American stock. The medical examiners may have a tendency to refuse policies to the older men who show most clearly marked evidences of senile changes.

* The means for the women apparently do not lie in a straight line. It is idle, however, to investigate the point farther on the available data.

In view of these facts, little significance is to be attached to the failure of the men in the medico-actuarial series to show a post-maximum shrinkage comparable with that observed in the criminals who were quite involuntary—not voluntary—applicants for measurement, who were not selected after measurement, and who were measured by experts for purposes of later identification instead of by general medical practitioners.

J. Arthur Harris.

SOME LANDMARKS IN THE HISTORY OF VITAL STATISTICS*

In the earlier volumes of the Journal of the Royal Statistical Society—those mines of curious information—a favorite form of contribution was the "tabular résumé," which presented a series of more or less statistical facts on a chronological base. With so distinguished a precedent it has seemed to me that the Quarterly Publications might care to present to its readers a small contribution in the same form, which I have recently drawn up for the use of my students in vital statistics.

This "tabular résumé" attempts to set forth in chronological array what seem to me to be some of the most important landmarks in the history of biostatistics. To disarm in some measure criticisms, which from the standpoint of the professional historian would otherwise be undoubtedly merited, I hasten to say, first, that there has been no slightest thought of encompassing within this short table a complete history of the subject. Historical completeness and the tabular form of presentation do not go well together. The object of the present table is much simpler. It is to get before the student the briefest conspectus of the time relations of the development of the subject on the one hand, and of the personalities concerned in a large path-breaking way in this development, on the other hand. The precise manner in which such an object will be carried out will obviously be different for each person who attempts it. One person's estimate as to the relative historical significance of a particular event or personality will differ from another's. In presenting the matter to my class I endeavor to justify in more detail than is possible in the table itself the particular items which appear. In any event, it seems clear that any historical review of vital statistics would be bound to contain at least a good many of the items of the present table. More than this in the way of agreement among scholars on a historical matter it is doubtless idle to hope for.

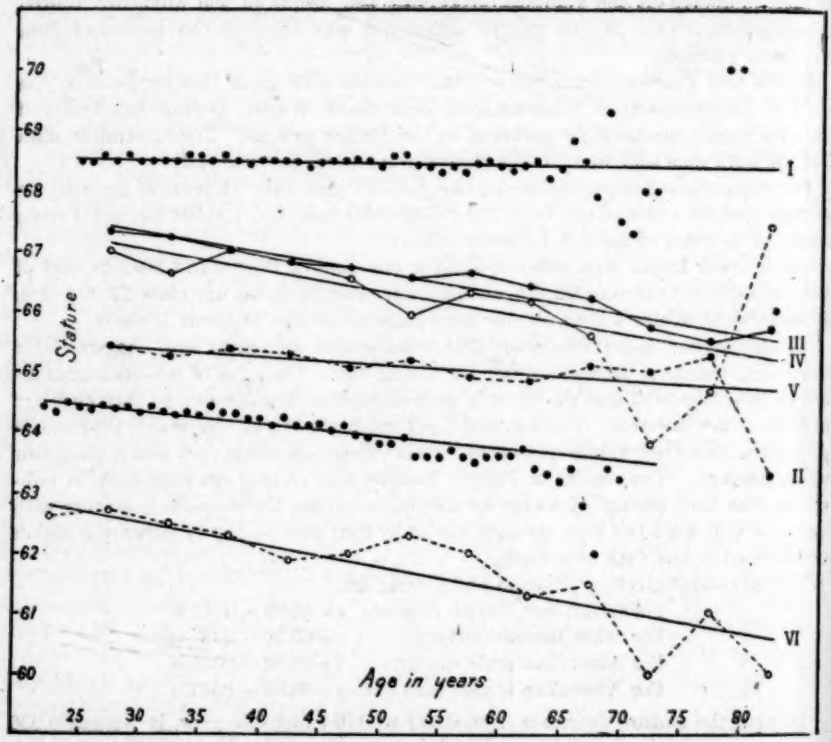
In the second place it should be said that if the sources chosen for statement of reference as to the fact are obviously in many cases second-hand, and perhaps somewhat casual, this is so of deliberate purpose. I am hopeful that by so choosing them I may perchance entice an unwary student or so to do a little reading about the men who have helped to develop modern statistics. I am quite sure that this will not happen if I refer him straight off to a ponderous and deadly "Geschichte der Statistik." Nor is there much chance that the embryo health-officer would make anything but very heavy weather if he essayed a voyage into the "*Theorie analytique.*" But if he will read the article in the Encyclopedia Britannica on Laplace he will tend to have a measure of wholesome respect for a great man and will know a little at least of what that man meant in the history of science.

* Papers from the Department of Biometry and Vital Statistics, School of Hygiene and Public Health Johns Hopkins University, No. 11.

are given for quinquennial age groups for the Australian and British series, but for each year in the medico-actuarial series.

The lines and the empirical means for the American series show a clearly marked post-maximum decrease in the stature of the women. This is somewhat smaller than, but otherwise comparable with that found in the British and Australian series.* In the men, however, the decrease in stature is very slight indeed.

The results for these very diverse series are in fair agreement with the exception of those relating to American men. The crudeness of the measurements has already been



I, American men; II, American women; III, New South Wales male criminals; IV, British fraudulent criminals; V, British convicts other than fraudulent; VI, New South Wales female criminals.

noted. Again, the data are for insured lives and are therefore a selected class. *A priori* there is no reason to assume that men of 60 years who apply for insurance are of the same social class as men of 20 to 30 years. Among the latter there may be a much larger proportion of recent immigrants or of the first generation from immigrant parents, distinctly differentiated in stature from the older American stock. The medical examiners may have a tendency to refuse policies to the older men who show most clearly marked evidences of senile changes.

* The means for the women apparently do not lie in a straight line. It is idle, however, to investigate the point farther on the available data.

In view of these facts, little significance is to be attached to the failure of the men in the medico-actuarial series to show a post-maximum shrinkage comparable with that observed in the criminals who were quite involuntary—not voluntary—applicants for measurement, who were not selected after measurement, and who were measured by experts for purposes of later identification instead of by general medical practitioners.

J. Arthur Harris.

SOME LANDMARKS IN THE HISTORY OF VITAL STATISTICS*

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TABULAR REVIEW OF SOME OF THE IMPORTANT EVENTS IN THE HISTORY OF VITAL STATISTICS

Year	Event	Personality Concerned	Authority for Record
1532	First definitely known compilation of weekly bills of mortality in London	——	Hull, C.H., Econ. Writ. of Sir W. Petty, p. lxxxi
1539	Beginning of official registration of baptisms, marriages and deaths in France	——	Faure, F. Hist. Stat. p. 242
1608	Beginning of oldest parish register in Sweden		Arosonius, E. Hist. Stat. p. 537
1662	Publication of first edition of "Natural and Political Observations Mentioned in a following Index, and made upon the Bills of Mortality"	Capt. John Graunt, Citizen of London (1620–1674)	Hull, C. H. Econ. Writ. of Sir Wm. Petty, p. 315
1666	First Census of Canada (The earliest modern census of population)		Godfrey, E. H. Hist. Stat. p. 179
1669	Application of mathematical theory of probability to expectation of human life	Christiaan Huygens (1629–1695)	Stuart, C. A. V. Hist. Stat. p. 430
1693	Publication of "Estimate of the Degrees of Mortality of Mankind," in the Philosophical Transactions of the Royal Society	Halley, the astronomer (1656–1742)	Hull, *Loc cit.* p. lxxvii
1713	Publication of "Physico-theology; or a demonstration of the Being and Attributes of God from his Works of Creation"	Rev. William Derham (1657–1735)	Hull, *Loc. cit.* pp. lxxvii and lxxviii
1718	Publication of the "Doctrine of Chances"	A. DeMoivre (1667–1754)	Art. DeMoivre, Encyc. Brit
1735	Registration of vital statistics begun in Norway		Kiaer, A. N. Hist. Stat. p. 447
1741	Publication of "Die göttliche Ordnung in den Veränderungen des menschlichen Geschlechts aus der Geburt, dem Tode und der Fortpflansung desselben erwiesen, etc."	Johann Peter Süssmilch (1707–1767)	Hull, *Loc. cit.* p. lxxviii
1746	Publication of the first French tables of mortality under the title "Essai, sur les probabilités de la durée de la vie humaine"	Deparcieux	Faure, F. *Loc. cit.* p. 265
1748	Beginning of Swedish official vital statistics	——	Arosonius, E. Hist. Stat. p. 540
1749	First complete Census of Sweden	——	Rossiter, W. S. Cent. Pop. Growth, p. 2
1753	First Census of population in Austria ordered	——	Meyer, R., Hist. Stat. p. 85
1769	First population Census of Denmark and Norway	——	Jensen, A. Hist. Stat. p. 201
1790	First federal Census of the United States		
1795	First Census of the Netherlands	——	Stuart, C. A. V. Hist. Stat. p. 43
1797	Establishment of Danish-Norwegian Tabulating Office	——	Jensen, A. *Loc. cit.* p. 201
1798	First complete Census of Spain	——	Rossiter, W. S. Cent. Pop. Growth, p. 2
1801	First complete Census of Great Britain	——	Rossiter, W. S. *Loc. cit.*
1801	First complete Census of France	——	Rossiter, W. S. *Loc. cit.*
1805	Formation of first statistical state office within boundaries of German Empire	——	Würzburger, E. Hist. Stat. p. 3
1810	First complete Cenus of Prussia		Rossiter, W. S. *Loc. cit.*
1812	Publication of "Theorie analytique des probabilités"	Pierre Simon Laplace (1749–1827)	Encyc. Brit. Art. Laplace
1812	Inauguration of civil registration of births, marriages and deaths in the Netherlands	——	Stuart, C. A. V. Hist. Stat. p. 432
1812 1826	Publication of "Theoria combinationis observationum erroribus minimis obnoxia" (Least squares)	Karl Friedrich Gauss (1777–1855)	Encyc. Brit. Art. Gauss
1815	First complete Census of Norway	——	Rossiter, W. S. *Loc. cit.*
1815	First complete Census of Saxony	——	Rossiter, W. S. *Loc. cit.*
1816	First complete Census of Baden	——	Rossiter, W. S. *Loc. cit.*
1818	First complete Census of Austria	——	Rossiter, W. S. *Loc. cit.*
1818	First complete Census of Bavaria	——	Rossiter, W. S. *Loc. cit.*
1825	Publication of "Mémoire sur les lois des naissances et de la mortalité à Bruxelles," Quetelet's first statistical paper	Lambert Adolph Jacques Quetelet (1796–1874)	Lottin, Quetelet, p. xx
1826	Establishment of statistical commission in Belgium	Ed. Smits	Julin, A. Hist. Stat. p. 126
1829	First official Census of Belgium	Ed. Smits	Julin, A. Hist. Stat. p. 128

TABULAR REVIEW OF SOME OF THE IMPORTANT EVENTS IN THE HISTORY OF VITAL STATISTICS.—*Concluded*

Year	Event	Personality Concerned	Authority for Record
1832	Publication of "Recherches sur la reproduction et sur la mortalité de l'homme aux different ages et sur la population la Belgique d'apres la recensement de 1829 (premier recueil officiel des documents statistiques)"	Quetelet and Smits	Lottin, *Loc. cit.* p. xxi.
1834	Royal Statistical Society (London) founded	———	Title page of Journal
1835	Publication of "Sur l'homme et le développement de ses facultés, ou Essai de physique sociale"	Lambert AdolpheJacques Quetelet (1796–1874)	Lottin, *Loc. cit.* p. xxi
1836	First complete Census of Greece	———	Rossiter, W. S. *Loc. cit.*
1837	Civil registration of vital statistics in England. Establishment of office of Registrar-General	———	Baines, A. Hist. Stat. p. 370
1837	Appointment of William Farr as compiler of abstracts in the Registrar-General's Office	William Farr (1807–1883)	Encyc. Brit. Art. Farr.
1838	Publication of "Essay on Probabilities" in Lardner's Encyclopedia	Augustus DeMorgan (1806–1871)	Encyc. Brit. Art. DeMorgan
1839	Organization of American Statistical Association		Hist. of Stat. p. 3
1846	Publication of "Analyse mathematique sur les probabilités des erreurs de situation d'un point." Acad. des Sci. Mem. par div. sav. IIe. Ser. t. ix (Correlation)	A. Bravais	Yule Introd. p. 188
1848	Foundation of the Institute of Actuaries of Great Britain and Ireland		Encyc. Brit. Art. "Actuary"
1860	First complete Census of Switzerland		Rossiter, W. S. *Loc. cit.*
1861	First complete Census of Italy		Rossiter, W. S. *Loc. cit.*
1863	Austria establishes Central Statistical Commission	Count Mercandin	Meyer, R. *Loc. cit.* p.89
1865	Publication of "History of Mathematical Theory of Probability from the Time of Pascal to that of Lagrange"	Isaac Todhunter (1820–1884)	Encyc. Brit. Art. Todhunter
1867	First creation of independent official statistical organization in Hungary		Buday, L. von. Hist. Stat. p. 395
1869	Publication of "Hereditary Genius"	Sir Francis Galton (1822–1907)	Art. Galton Encyc. Brit.
1869	Foundation of Société de statistique de Paris		Title page of Journal
1872	Opening of German Imperial Statistical Office		Würzburger, E. Hist. Stat. p. 337
1881	First general Census of India		Baines, A. Hist. Stat. p. 421
1887	Royal Statistical Society incorporated by Royal Charter		Title page of Journal
1890	First Census in which mechanical methods of tabulation were used	John S. Billings and Herman Hollerith	Rept. Supt. Census 1890, p. 8
1894	Publication of first of "Contributions to the Mathematical Theory of Evolution" in Phil. Trans. Roy. Soc.	Karl Pearson	Title page
1897	Publication of paper "On the Theory of Correlation" in the Jour. Roy. Stat. Soc.	G. Udny Yule	Jour. Roy. Stat. Soc. Vol. LX, p. 812
1897	First Census of Russia	———	Kaufman, A. Hist. Stat. p. 481
1900	First year of separately published official mortality statistics for Registration Area of United States		Title page of "Mortality Statistics"
1901	Publication of first number of Biometrika	Francis Galton Karl Pearson W. F. R. Weldon C. B. Davenport	Title page
1902	Creation of permanent Census Bureau in the United States	———	Cummings, J. Hist. Stat. p. 682
1915	First year of separately published official birth statistics for Registration Area of United States	———	Title page of "Birth Statistics"

EXPANDED TITLES OF REFERENCES CITED IN TABLE

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The History of Statistics, Their Development and Progress in Many Countries. Collected and edited by John Koren. New York (Macmillan). 1918.

Yule, G. U. Introduction to the Theory of Statistics. Fifth Edition. London (Griffin & Company). 1919.

RAYMOND PEARL.

NATIONAL BUREAU OF ECONOMIC RESEARCH, INC.

The National Bureau of Economic Research, Inc., with offices at 175 Ninth Avenue, between 20th and 21st Streets, New York City, has been organized to meet a growing demand for exact and impartial determinations of those facts which bear upon economic, social and industrial problems. While it seeks only to determine facts, its investigations must be carried on in such manner and under such supervision as to make its findings carry conviction to liberals and conservatives alike. For this reason, it is precluded by its Charter from becoming an agency for the profit of its members, directors, or officers, and by rigid provisions in its By-Laws, from becoming an instrument for propaganda. And it assumes no obligation to present or future contributors except to make accurate determinations of facts and to publish the results of its investigations.

The initial investigations of the bureau are expected to deal with the distribution of income in the United States among individuals and by basic sources—wages and other returns for personal service, interest, land rents, and profits in excess of a normal interest rate. A knowledge of this distribution is of vital consequence in the consideration of almost every important political, social, and industrial problem, and will be of particular value in relation to the many questions of taxation, legislation, and industrial readjustment that are now pressing for solution.

In general, the investigations made will deal with topics of national importance, regarding which quantitative analysis is feasible, with the object of placing as much as possible of present-day discussion on a basis of fact, as distinguished from more or less partisan opinion. While the selection of subjects to be investigated in the future rests with the directors, the following problems may be taken to illustrate the probable range of the bureau's activities: The details of excess profits and income taxes, and their economic reactions; changes in the physical productivity of labor under varying conditions of employment; fluctuations in the percentage of idle machinery and unemployed labor; the distribution of property ownership; the relation of the productive capacity of the country to its industrial needs; the relations between demand for goods and prices; selling costs compared with costs in various industries; rates of return necessary to attract investments of capital; the economic effects of immigration; foreign investments of capital in the United States and American investments in foreign countries. It should be emphasized that there is no existing institution today equipped to undertake fundamental researches of the type outlined from a disinterested point of view, whose findings will be generally accepted.

The bureau will, furthermore, be specially equipped to undertake commissions for investigations desired by individuals, corporations or associations, and it is one of its major purposes to afford the means through which such special investigations may be conducted on a basis to assure widespread confidence in the results. Such special investigations must, however, be in line with the general purposes of the bureau and the bureau will reserve in all cases the unrestricted right to publish its findings.

The research work will be carried on by Wesley C. Mitchell, as Director, Wilford I. King, Frederick R. Macaulay, and an adequate staff of investigators and computers. Its management is in the hands of a board of nineteen directors of whom ten are directors at large, and nine directors by appointment.

The initial directors at large are the following:

Edwin F. Gay, formerly Dean of the Harvard Graduate School of Business Administration, and now President and Editor of the *New York Evening Post*.

Wesley C. Mitchell, formerly Professor of Economics at Columbia University,

recently in charge of the preparation of a "History of Prices During the War" for the Federal Government, and now Treasurer of the New School for Social Research.

John R. Commons, formerly President of the American Economic Association; also a member of the Industrial Commission of Wisconsin, 1911–1913, and of the Federal Commission on Industrial Relations 1915–1918; and now Professor of Political Economy at the University of Wisconsin.

N. I. Stone, formerly Chief Statistician of the U. S. Tariff Board; later a member of the U. S. Tariff Commission, sent to Germany in 1906; and now Labor Manager for Hickey-Freeman Company of Rochester, N. Y.

Allyn A. Young, formerly President of the American Statistical Association, now Secretary and Treasurer of the American Economic Association and Professor of Economics and Finance at Cornell University.

John P. Frey, Editor, International Molders' Journal of Cincinnati, Ohio, and prominent in the activities of the American Federation of Labor.

T. S. Adams, formerly a member of the Wisconsin Tax Commission, now Professor of Political Economy at Yale University and Adviser to the U. S. Treasury Department on matters of taxation.

Elwood Mead, formerly Chairman of the State Rivers and Water Supply Commission, of Victoria, Australia, and now Professor of Rural Institutions at the University of California; also Chairman of the Land Settlement Board, and consulting engineer for various irrigation and waterworks companies.

J. E. Sterrett, member of the firm of Price, Waterhouse and Company of New York City, public accountants, and for some time engaged in war and reconstruction service of the U. S. in this country and abroad, and Adviser to the U. S. Treasury Department on matters of taxation.

Harry W. Laidler, Secretary of the Intercollegiate Socialist Society.

Directors at large are elected for five-year terms by the whole body of directors.

In addition, the following organizations have nominated independent directors as follows: Professor David Friday has been appointed by The American Economic Association, Mr. Frederick P. Fish by The National Industrial Conference Board, Mr. Walter R. Ingalls by The Engineering Council, Mr. George E. Roberts by The American Bankers Association, Mr. M. C. Rorty by the American Statistical Association, and Mr. Hugh Frayne by the American Federation of Labor. The other institutions have not yet taken action.

The officers of the Bureau are as follows:

President, Edwin F. Gay
Vice-President, John P. Frey
Director of Research, W. C. Mitchell
Treasurer, M. C. Rorty
Secretary, Oswald W. Knauth

Executive Committee

E. F. Gay, *ex-officio* — John P. Frey, *ex-officio*
T. S. Adams — J. E. Sterrett
H. W. Laidler

THE CENTRAL STATISTICAL BUREAU OF THE BALTIMORE ALLIANCE

At the beginning of the present year the Baltimore Alliance, a federation of some fourteen organized social or charitable agencies in the City of Baltimore, under the direction of Major Wm. Burnet Wright, Jr., who has recently accepted the post of

permanent director of the Alliance, organized a new department of potentially far-reaching importance. It will be known as the Central Statistical Bureau, and will form an integral part of the Alliance. The functions of this bureau are (1) to supervise, standardize, and control the permanent statistical records collected by each of the allied agencies; (2) to serve as the final repository of all case and statistical records; (3) on the basis of the critically controlled basic statistical records to carry on scientific investigations of those broad social problems, towards the ultimate solution of which the activities of the Alliance are directed.

Dr. Raymond Pearl, Head of the Department of Biometry and Vital Statistics in the School of Hygiene and Public Health of Johns Hopkins University, has been appointed Director of the Central Statistical Bureau, and Miss Magdalen H. Burger, formerly chief of the retail price section of the Statistical Division of the United States Food Administration has been appointed Chief Statistician. Funds have been provided for the necessary clerical staff. An advisory statistical committee which is in process of formation, will include among others, Dr. George E. Barnett, Professor of Statistics in Johns Hopkins University, and Dr. W. H. Maltbie, Director of the Bureau of Municipal Research. The bureau will be housed with the Department of Biometry and Vital Statistics of the School of Hygiene, at 625 St. Paul Street, Baltimore.

It is to be expected that with the passage of time there will accumulate in this bureau a set of records which will offer unique opportunities to graduate students and others wishing to undertake fundamental investigations of poverty, disease, and other social problems now retarding community health, well-being and happiness.

BRITISH EMPIRE STATISTICAL CONFERENCE AT LONDON

As early as 1907, the lack of comparability and homogeneity in the statistics of the British Empire was the subject of comment by the Imperial Conference, and in 1913, the "Dominions Royal Commission," a body set up by the conference for the comprehensive study of inter-Imperial economic relations, reported definitely in favor of a meeting of statisticians of the Empire, the object being to reduce, if not eliminate, the differences in statistical method which prevailed between the several units, to level up where possible the gaps and inequalities which existed, and *in fine* to discuss the feasibility of a permanent statistical bureau for the British Empire. Such a bureau, it was considered by the commission, was essential for the maintenance of proper co-ordination and development, and in fact for the creation of a true Imperial statistic. The war postponed action on this recommendation, but it was placed by the Imperial War Conference of 1918 in the forefront of inter-Imperial business to be taken up on the declaration of peace.

The conference duly met in London on January 20, 1920, under the presidency of the U. K. Board of Trade, and sat for a period of six weeks, finishing on February 26. It consisted of representatives of twenty-three departments of the government of the United Kingdom, the chiefs of the central statistical departments of the following self-governing Dominions, namely, Canada, Australia, South Africa and New Zealand, the director of statistics of India, and a representative from each of the following groups of Crown colonies and protectorates: Eastern Colonies, East African Colonies, West African Colonies, West Indian Colonies. The chairman of the Imperial Mineral Resources Bureau was also a representative, and the conference had the advantage of the attendance of various government experts and professional statisticians. Altogether twenty-four sessions of the full conference were held, proceeding for the most part on reports of committees, of which nine were created exclusive of sub-committees.

In addition a meeting was held with the general secretary of the League of Nations to discuss the relations of the contemplated Empire organization of statistics to the plans which are preparing for international statistics.

First place was given by the conference to the consideration of the question of a British Empire Statistical Bureau. The opinion of the conference was unequivocally in favor of the early establishment of such a bureau "for the purpose of obtaining, collating, examining and publishing statistics which bear upon the conditions and resources of the Empire, the common interests of its members and their relations with the rest of the world." Such statistical information, it was suggested, would cover but would not be limited to the following, demography, labor, industrial and general social statistics, production, commerce (foreign and domestic), transport and communication, finance (including currency and banking) and public administration. In order to perform this function efficiently the bureau would in the first instance receive copies of all statistical data prepared within the Empire and suggest such changes from time to time in form and content as would facilitate coördination and insure comprehensiveness, the secondary object being to link together the various central statistical bureaus (or where such do not exist, the larger independent offices), and assist them with advice. Its publications would consist in the main of an annual statistical review of the Empire, with annual or quarterly abstracts of the more important Empire statistics, and periodical monographs on special subjects.

With regard to the constitution of the bureau, the conference recommended that it be incorporated by Royal Charter under the presidency of the Prime Minister of the United Kingdom (as *ex-officio* president of the Imperial Conference), and that it be administered and controlled by a "Council" of members, nominated by the several governments assenting. The practical management of the bureau is to be in the hands of a director ("who should be both an expert statistician and a man of proved administrative and official experience and ability") to be appointed by the Council, in consultation with the governments concerned. For his assistance, an "Advisory Committee" is proposed consisting of members of the Council, the chairman of the Imperial Mineral Resources Bureau and other coöpted occasional members, representing commercial, industrial and financial interests. The suggestion is also made that to provide the necessary professional assistance and at the same time effect a liaison between the Central Bureau and the outlying portions of the Empire, the director should secure certain members of his staff for determinate periods from the staffs of the Indian and Dominion Statistical Offices, by arrangements between himself and the chief statistician of each country, with the consent of the government concerned. Similarly officers of the bureau may be secured for work in the Dominion Offices. It is estimated that the cost of operating such a bureau would be in the neighborhood of $150,000 per year.

Not less important was the series of resolutions passed by the conference dealing with actual statistical procedure. Examination was made of the general field of statistics comprised under the headings above mentioned. Space is available for only the briefest statement of these recommendations:

General.—Resolutions were passed defining in general terms the functions of a statistical office, calling for the publication of all questionnaires, advocating the extension of compulsory powers, and suggesting the improvement of statistical organization in certain Colonies and Protectorates. The report of a special committee making detailed comments and recommendations as to the Blue Books prepared in the various Colonies and Protectorates was adopted.

Trade.—The statistical year, the valuation of imports and exports, the registration

of imports and exports by countries, uniform classification, transit and transhipment trade, government stores, parcel post and the format of annual and monthly trade returns, were the subject of special resolutions.

Production.—Twenty-four resolutions were devoted to various aspects of agricultural, fisheries, forestry, mining and manufacturing statistics. Among other recommendations, a quinquennial census of agriculture is called for, and an annual calculation of agricultural values to show (a) the value to the producer, and (b) the commercial value to the country. The resolutions on mining include the following:

"The value of mine products for statistical purposes should be that at the mine itself, regardless of any treatment that the product may undergo after leaving the mine.

"For the purposes of statistics of production, mining production should be distinguished from reduction, smelting and other refining or treatment processes, statistics as to which should be included in statistics of factory production."

Demography.—Twenty resolutions dealt with the population census and with vital and migration statistics. A quinquennial census *de facto*, on an approximately uniform census day, under permanent legislation, was advocated. To the problem of uniform classification and listing of industries and occupations, the conference devoted special attention and reported in considerable detail. Various recommendations as to particulars to be obtained by the census inquiry and the improvement of vital and migration statistics were made.

Prices and Index Numbers.—Perhaps the most important of the seven resolutions passed under this heading had to do with the method of constructing index numbers. It was resolved that the "index-numbers should be so constructed that their comparison for any two dates should express the proportion of the aggregate expenditure on the selected list of representative commodities, in the quantities selected as appropriate, at the one date, to the aggregate expenditure on the same list of commodities, in the same quantities, at the other date." The adjustment of index-numbers to changes in national consumption was also dealt with.

Labor Statistics.—A scheme of labor statistics for the Empire was outlined and a resolution passed advocating that the proposed Imperial Bureau should act, wherever feasible, as medium for transferring such data to any international labor conference, so that the data in question might be available for Empire purposes not later than for general international purposes.

Finance.—The resolutions dealt with budget and debt statistics, income and capital, currency and specie, movements of capital, banking, prices of securities, insurance, and the financial operations of credit institutions in general.

Altogether ninety-seven resolutions were passed by the conference, the effect of which, apart from the specific project of an Empire Bureau, has been to chart a course by which the main statistical activities of the various countries of the Empire may be directed for some time to come. It is proposed that the conference should re-assemble every five years for review of its decisions, and for report, should the proposed Empire Bureau materialize, on the latter's progress and general policy. It may be remarked that the resolutions of the conference were in most cases adopted without dissentient voice and that all its conclusions were arrived at with substantial unanimity. Not least of the benefits already derived have been the establishment of direct personal intercourse between the representatives of the different countries, and the general stimulation imparted to statistical work throughout the Empire. A report of the proceedings and resolutions of the conference has been printed.

R. H. Coats.

THE INADEQUACIES AND NEEDS OF BRITISH STATISTICS

In November, 1919, a petition was submitted to His Majesty's Government setting forth the inadequacies of official statistics for the United Kingdom and the British Empire, and suggesting the appointment of a commission to make an inquiry for the purpose of effecting a reorganization of the existing statistical system. The defects which the petition sets forth briefly and clearly, are of such interest that the petition is presented in full in the following paragraphs. The names of the petitioners are those of a long list of distinguished individuals, and also representatives of various learned bodies and societies, of county and municipal authorities, of medical offices and public health committees, of chambers of commerce, and of various companies and firms.

"1. The undersigned Petitioners desire respectfully to represent to His Majesty's Government the urgent need of a reorganisation of the present system of official statistics as the foundation of a proper system of civil intelligence, in the first place for the United Kingdom, and in the second place for the British Empire.

"2. It is generally recognised by statesmen, publicists, writers and students, that official statistics, as at present collected and published, are inadequate in arrangement and scope for the purposes they should serve, in spite of the efforts and ability of individual official statisticians.

"3. Amongst the causes which have been suggested in different quarters are the following: (i) Absence of any general supervision of national statistics as a whole. (ii) Lack of co-operation between the different departments, except so far as this may be arranged on a voluntary basis. (iii) The fact that compulsory powers are too few and too seldom applied. (iv) Defective supervision of the collection of statistics in some cases, and the employment, especially for census purposes, of persons ill-paid and insufficiently educated and therefore uninterested in the collection. (v) Antiquated and anomalous legislation, such as that which prescribes different financial years for various annual returns. (vi) Inadequate financial provision for the collection of essential statistics.

"4. The attention of the Royal Statistical Society has been called from time to time by some of its officers and members to the imperfection of official statistics. In 1871, Mr. Purdy, one of the Secretaries of the Society, recommended the institution of a central statistical office. In 1907, Sir Charles Dilke, in his Presidential address to the Society, pointed out that there had been little general improvement since 1880 and advocated a permanent statistical control. Similar conclusions were reached in a paper read before the Society in 1916 by one of the Vice-Presidents, Mr. Geoffrey Drage. In June, 1919, the Council of the Society appointed a Committee on Official Statistics consisting of Mr. Geoffrey Drage (Chairman), the Rt. Hon. Herbert Samuel (President of the Society), Dr. A. L. Bowley, Dr. J. C. Stamp, C.B.E., and Mr. A. W. Waterlow King, to press for a Parliamentary inquiry into the whole subject, with general power to act. The result is the present petition, for which, however, the signatories are alone responsible.

"5. The following examples of defects in statistics have been adduced: (i) There is no general information as to wages since the incomplete census of 1906. This census, the census of production in 1907, and the census of population in 1901 and 1911 are not collated, so that there is no definite means of knowing at any date how many wage-earners there are, what they produce, how much they earn and how many people are dependent on them. (ii) There is no information as to the number or income of persons who neither earn wages nor are assessed to income tax, because its collection does not fall within the scope of any existing department, and in consequence

the aggregate of national income can only be roughly estimated. (iii) The statistics of home production are very incomplete. In the only census of production of which the report is published, that of 1907, the amounts paid in wages were not obtained. (iv) The railway traffic statistics are so jejune that they are useless either as an index of the trade of the country or for the purpose of international comparison. (v) The trade between England and Ireland is imperfectly known. (vi) There is no official statement of the number of trained seamen in the British mercantile marine. (vii) The number and class of houses available cannot be accurately ascertained from any official publication, nor is there any record of the number of houses built year by year. (viii) Information with regard to consumption of food, clothing and other necessaries is almost entirely wanting. Such illustrations could easily be multiplied. It is almost universally the case that persons engaged in any serious investigation have to rely on roughly approximate estimates in relation to one or more essential factors.

"6. With regard to the Empire similar difficulties occur, though, owing to constant agitation in recent years, some reforms have been secured. It was pointed out to the Dominions Royal Commission of 1912 that there was still a pressing need of (i) a common statistical year, (ii) a common statistical method, including a common method of classification, *e. g.* of metals and textiles, estimation of value and record of the origin and destination of goods, (iii) an annual report of the trade of the Empire on a scale sufficiently large to give adequate details of the trade of the overseas dominions, (iv) some reliable criterion of trade and production and some means of establishing satisfactory comparisons between the productive powers of the several states of the Empire.

"7. Now that the war is over and that there are in the air so many projects of reform both social and commercial, it has become more than ever necessary to provide a system of civil intelligence based on sound statistics which will help to show not only the cost of proposed social reforms, but also the results of changes in our commercial system. It is not too much to say that there is hardly any reform, financial, social or commercial, for which adequate information can be provided with our present machinery, and the same is true with regard to changes that have been proposed in our commercial relations with the overseas dominions and foreign countries.

"8. YOUR PETITIONERS SUBMIT *that the questions raised in this memorial are of sufficient importance to justify an immediate inquiry by a Royal Commission or Parliamentary Committee, and they suggest that such Commission or Committee should forthwith be appointed to inquire into the existing methods of the collection and presentation of public statistics and to report on the means of improvement.*"

PROGRAM FOR NEXT ANNUAL MEETING

A committee, whose names are published in this issue, has been appointed by the President to arrange a program for the next annual meeting. Members of the Association are urged to send to the Secretary's office or to any member of this committee suggestions for papers and discussions. The committee will appreciate the coöperation of members in various fields of statistical work in making the annual meeting interesting to all.

PUBLICATION ON THE CONSTRUCTION OF MORTALITY TABLES

A translation from the Danish of the researches of Mr. Arne Fisher on the construction of mortality tables by means of compound frequency curves is now being made by Mr. Vigfusson. This translation is to be printed through the enterprise of the "Scandinavian Insurance Magazine," and will probably be ready before the end of the year, published by Macmillan Co. The forthcoming volume will contain a number of mortality tables relating to widely different populations, such as Massachusetts males, 1914–1916, American Locomotive Engineers, 1913–1917, American Coal Miners, 1913–1917, Industrial Insured Males of the Metropolitan, 1911–1916, Assured Japanese Lives of fourteen Japanese companies, 1913–1917, and others. These tables are of particular interest as they have been prepared from mortuary records exclusively, and with no knowledge of the number of lives exposed to risk. This method was presented briefly in America in a paper read before the Casualty Actuarial Statistical Society of America, under the title "Note of the Construction of Mortality Tables by means of Compound Frequency Curves," and was presented later in some lectures at the University of Michigan. The novelty of the method has been commented upon with interest, and some appreciative reviews of the proposed scheme have appeared in English, Japanese, Belgian and Swiss statistical periodicals. The forthcoming book will be looked forward to with great interest. A. E. V.

APPOINTMENTS ON COMMITTEES FOR 1920

In addition to those published on the cover of the QUARTERLY, the following appointments have been made:

Committee on Program for next Annual Meeting:
- Wesley C. Mitchell, Chairman
- Robert E. Chaddock
- Earle Clark
- William F. Ogburn
- Warren M. Persons
- George E. Roberts
- Walter F. Willcox

Committee on Fellows:
- Leonard P. Ayres, for five years, to take the place of E. Dana Durand, whose term expired 1919.

The full Committee is constituted as follows:
- Frederick L. Hoffman, term expires 1920
- Adna F. Weber, term expires 1921
- Edward L. Thorndike, term expires 1922
- Carroll W. Doten, Chairman, term expires 1923
- Leonard P. Ayres, term expires 1924

Committee on Nominations:
- Edmund E. Day, Chairman
- Joseph A. Hill
- N. I. Stone

Committee on Business Statistics:
- Malcolm C. Rorty, Chairman
- Willard C. Brinton
- Earle Clark

Edith Miller
Warren M. Persons
Horace Secrist

Committee on Criminal Statistics:
Louis N. Robinson, Chairman
Edith Abbott
Robert H. Gault
Horatio M. Pollock

NEW MEMBERS OF THE AMERICAN STATISTICAL ASSOCIATION ELECTED SINCE FEBRUARY 1, 1920

Altmeyer, A. J., Industrial Commission, Madison, Wis. Chief Statistician of same.

Anderson, George P., Packard Motor Car Co., Detroit, Mich. Charge of special factory statistical reports.

Arnold, LeGrande Jenks, 14 Wall St., New York City. Financial accounting with Thompson & Black.

Atwater, Henry G., American Tel. & Tel. Co., 195 Broadway, New York City. Development and presentation of rates, etc.

Barnard, Chester I., American Tel. & Tel. Co., 195 Broadway, New York City. General charge of research in connection with telephone rates.

Barrow, David F., University of Georgia, Athens, Ga. Teaching mathematics.

Barry, Shepard E., 210 Wisconsin St., Milwaukee, Wis. General Auditor and member of the Office Committee, The Northwestern Mutual Life Ins. Co.

Beckmann, Senta Bertha, 18 E. 41st St., New York City. Supervision of statistics for Writing Paper Mfg. Assn., Tissue Paper Mfg. Assn., Cover Paper Mfg. Assn., and Book Paper Mfg., Associations.

Bennett, Mildred V., 15 E. 40th St., New York City. Manager Dept. Survey & Statistics, Community Service Inc.

Berger, Edla G., Searchlight Library, 450 Fourth Ave., New York City. Member of statistical force employed by the Library in connection with the report of the activities of the Y. M. C. A. in France.

Breitinger, Chas. MacC., 1000 Chestnut St., Philadelphia, Pa. Head of Statistical Dept. of the Philadelphia Electric Co.

Brownrigg, W. G., Room 1114, Arlington Bldg., Washington, D. C. Charge of statistical work, Bureau of War Risk Insurance.

Clarke, Allan V., 120 Broadway, New York City. Asst. to Statistician, International General Electric Co.

Cobb, Margaret V., National Research Council, 1201–16th St., Washington, D. C., Elementary School Intelligence Examination Board.

Comstock, W. Phillips, 910 Michigan Ave., Chicago, Ill. Statistical work of the Continental Casualty Co.

Conant, Luther, Jr., 91 Bacon St., Winchester, Mass.

Correa, Fred B., 817 Standard Oil Bldg., San Francisco, Cal. Sales analysis Standard Oil Company.

Criscuolo, Luigi, Room 3133, 120 Broadway, New York City. Investment banking, analysis of investment securities.

Cross, C. F., 1120 Boston Bldg., Salt Lake City, Utah. Secretary and Actuary of Inter-Mountain Life Ins. Co.

Davis, Frank H., Register Tribune Bldg., Des Moines, Iowa. Actuary, Merchants Life Ins. Co.

Davis, Joseph S., 474 Widener Library, Cambridge, Mass. Teaching and research, Harvard University.

Eames, Fred. M., State Commission of Highways, Albany, N. Y. Assistant Engineer in above Commission.

Fischler, Joseph, 133 W. 23rd St., New York City. Managing Statistician of the Graphic Service Bureau.

Frizell, Arthur Bowes, 38 Harvard St., Worcester, Mass. Instructor in mathematics, Worcester Polytechnic Institute.

Furbush, Edith M., 50 Union Square, New York City. Statistical Department of the National Committee for Mental Hygiene.

Gault, Robert H., Northwestern University, Evanston, Ill. Professor of Psychology.

Gavett, G. Irving, University of Washington, Seattle, Wash. Teaching mathematics.

Gerdy, Irving, 50 Pine St., New York City. Securities and investment, with Case, Pomeroy & Co.

Gilman, Stephen, 2626 South Michigan Ave., Chicago, Ill. Member of firm of certified accountants.

Glenzing, William L., Geo. Batten Co. Inc., 381 Fourth Ave., New York City. Advertising, market and merchandising statistics.

Hood, Frazer, Old College, Northwestern University, Evanston, Ill. Professor of Psychology.

Hoopingarner, Newman L., Carnegie Institute of Technology, Pittsburgh, Pa. Bureau of Personnel Research in above.

Hoppock, C. A., 61 Broadway, New York City. Market research work in connection with advertising, with firm of H. K. McCann Co.

Hyde, Duncan C., Harvard University, Cambridge, Mass. Graduate student in economics.

James, Virginia, Bureau of Education and Research, American Red Cross, St. Louis, Mo. Compiling a Handbook of Social Resources for each of the states of the Southwestern Division.

Klein, Philip, American Red Cross, 249 Ivy St., Atlanta, Ga. Director of Activities covering Training for Social Work.

Kimber, Albert W., 52 Broadway, New York City. President of A. W. Kimber & Co., Financial Statisticians.

Kingsland, T. Frazer, 108 Hudson St., New York City. Graphic Control, Borden Company, Charting sales and costs.

Kirkpatrick, Arthur Loomis, 45 William St., New York City. Insurance statistics, Globe Indemnity Co., Casualty Ins.

Loomis, Robert H., 525 Boylston St., Boston, Mass. Asst. Professor of Economics at Boston University, College of Business Administration.

Luce, Franklin H., Union Stock Yards & Transit Co., Chicago, Ill. Compilation of various statistical data gathered from live stock industry.

Mayer, Richard B., 95 Madison Ave., New York City. Statistician, The Blackman Co., Advertising Agency.

Miller, William J., Western Electric Co., Hawthorne Station, Chicago, Ill. Production Supervisor.

Murti Rao, M., Bangalore, South India. Fellow Royal Statistical Society, Statistician, Education Department, Bangalore, South India.

Nichols, Louis M., 120 Broadway, New York City. Chief Statistician, International General Electric Co.

Oberle, William E., 737 Commercial Trust Bldg., Philadelphia, Pa. Presidents Conference Committee, Federal Valuation of Railroads in the United States.

Peck, Paul N., U. S. Bureau of Efficiency, Washington, D. C.

Pierpont, Austen, 130 E. 22nd St., New York City. Dept. of Surveys and Exhibits, Russell Sage Foundation.

Quick, William F., 26 Broadway, New York City. Statistical work for the Annuities and Benefits Committee, Standard Oil Company.

Ramsdell, Leroy A., New York School of Social Work, New York City. Community Organization Assistant and Field Secretary, Atlantic Division, American Red Cross.

Randolph, B. W., 95 Madison Ave., New York City. Director of Commercial Research, The Blackman Co.

Roelse, Harold V., Bureau of Statistics, N. Y. State Industrial Comm., Albany, N. Y. Asst. to Chief, Division of General Statistics.

Ruml, Beardsley, 751 Drexel Bldg., Philadelphia, Pa. Director, The Scott Company Laboratory. Consultant in Personnel Management.

Schmitz, Val A., George Batten Co., 381 Fourth Ave., New York City. Connected with Commercial Research Dept. of above.

Schroll, Luther, Jr., Aniline Dyes & Chemicals Inc., New York City. Preparation of statistical charts and statements.

Shelton, W. Arthur, Bureau of Statistics, Interstate Commerce Comm., Washington, D. C. Statistical research for above.

Sibley, John L., 80 Maiden Lane, New York City. Charge of Statistical Dept. United States Casualty Co.

Simon, Leon Gilbert, 120 Broadway, New York City. Research work in insurance statistics.

Stannard, J. W., American Autoparts Co., Detroit, Mich. Financial work in above company and American Steel Foundries, Chicago, Ill.

Stellwagen, Herbert P., American Tel. & Tel. Co., 195 Broadway, New York City. Accounting Dept. and Statistical Division.

Stevens, Edwin B., University of Washington, Seattle, Wash. Executive Secretary of University.

Stevenson, T. Kennedy, Western Electric Co. Inc., 195 Broadway, New York City. Sales statistician.

Stewart, Walter W., Amherst College, Amherst, Mass. Professor of Economics.

Thurstone, Louis L., Carnegie Institute of Technology, Pittsburgh, Pa. Teaching Psychology, Statistics and Mental Test Technique.

Tryon, Frederick G., U. S. Geological Survey, Washington, D. C. Division of Mineral Resources. Charge of Coal and Coke Statistics.

Valentine, Frederic, American Tel. & Tel. Co., 195 Broadway, New York City. Rate Research.

von Huhn, R., 25 Broad St., New York City. Statistical Dept., William Salomon & Co.

Weyforth, Wm. O., Johns Hopkins University, Baltimore, Md. Teaching Business and Social Statistics.

Williams, E. P., 1507 Mallers Bldg., Chicago, Ill. Bureau of Market Analysis Inc.

Wolfe, French E., Syracuse University, Syracuse, N. Y.

A CORRECTION.

At the 81st Annual Meeting of the Association, the Proceedings of which were published in the March QUARTERLY of this year, the death of one of our honorary members, Dr. Louis Guillaume, Berne, Switzerland, was announced. We are glad to inform our readers that this was an error, and we express regret for the mistake.